BULLETIN

OF THE

Scientific Laboratories

OF

DENISON UNIVERSITY.

VOLUME IX.

PARTS I AND II.

EDITED BY

W. G. TIGHT, M. S.,

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

GRANVILLE, OHIO.

December, 1895—March, 1897.

TABLE OF CONTENTS.

VOL. IX.

PART I.

With 2 Maps.

PART II.

With 11 Plates and 5 Figures.

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I.

THE PALAEOZOIC FORMATION.

W. F. Cooper.

No subject open to our investigation is more interesting or economical than that department of inorganic geology embraced under its stratigraphical relations. The conditions attending the origin and deposition of the earth's crust are at the basis of our existence in a certain sense; that is leaving out the ethical element which it is hoped one may consider as the pre-existing state necessary for such physical operations as should best fit man for his abode throughout his entire cycle of life.

Whatever may be the relations sustained by our planet with the rest of the solar system, through the so-called nebular hypothesis; it is suggestive to follow out the comparisons of W. Prinz published in the *Annuaire de l' Observatoire Royal de Bruxelles* for 1891, in which the great continental torsions of the western coasts of America, Europe and Africa, western Siberia through the corresponding coast line of Australia, together with a fourth supposed by him to be indicated by the great chain of islands to which the Marshall group belongs; has been thought to be analagous with similar oblique lines observed on Mars, and less distinctly on Venus and Jupiter.

The similarities afforded by each of the three great continental systems is suggestive as bearing upon the similar primary condition attending their origin and fundamental development. We have counterparts in the respective irregular triangular outlines of North America, Europe, and Asia, in connection with the formation of South America, Africa, and Australia, all with a more or less triangular development, and with the apex of the triangle pointing southward. Similarly as the outlines become less triangular and larger from west to east, we have regularly separating bodies of water also increasing in size, and represented by the Gulf of Mexico, Mediterranean, and the Indian Ocean. The existence of greater depths in the western Atlantic and Pacific, in connection with corresponding altitudes on both of their immediate shore lines, may indicate a great law of stratigraphic equivalence or equilibrium, through which as we already

know, great accumulations result in areas of elevation, while vice-versa, lesser deposits might be held as forming the lowest depths. James D. Dana has attributed the zigzag arrangement of continents to torsion with the maximum torsion represented by a belt of volcanoes, and the earth's feature-lines as consequences in part of the pressure or tension attending torsion.

In our own country it can be readily shown that the North American continent had attained the outlines of its present form at the close of the Archaean age, subsequently developing southward into the Appalachian axis; that westward from there the surface deposits prove that it was coexistent with Carboniferous time, while west of a line drawn from the eastern longitude of Dakota the great Mesozoic and Tertiary deposits took place, the great climax of physical activity resulting in the evolution of the Mesozoic age, together with lesser resultant actions at the close of the Tertiary, or during a period very nearly contemporaneous with the Glacial epoch. Coexistent with this, it should also be observed that deposition took place from the north to the south, leaving the southern states adjacent to the Atlantic, Gulf of Mexico, and the Rio Grande of Tertiary and other later formations. We have attempted to show in a very general way the course of development among the sedimentary rocks, and it is thought, that as the general development has been westward. so we may be able to indicate the origin more exactly of portions of the Palaeozoic strata from sources eastward of their main deposition.

Any consideration of the origin of the later fragmentary rocks, involves not only an account of the adjacent land areas, but also the agencies by which they might be removed. The argument of Mr. Bull that the denuding action of tides must have been much greater among the rocks under discussion, cannot apparently find any very strong substantiation in nature, either from an organic or physical basis. Mr. Bull supposes that on account of the greater proximity of the moon at this time, that the action of tides would be greatly increased, causing material to be eroded and deposited in a manner almost inconceivable at the present. There are three objections to this theory: Primarily, that the nebular hypothesis of Laplace involves the fundamental idea that heat is evolved as a result of contraction, not taking into account that the intense heat of the sun would be more apt to cause an expansion instead of contraction along its diameter, according to all the known laws of Physics, while this involves indi-

rectly the relation of our satellite to the earth, and it to the sun. There is moreover, no physical action apparent, with the exception of some cases which will be observed, which would denote any violent physical force. Most of the strata of the Palaoezoic and Mesozoic were deposited during periods when life was very abundant, and its manner of preservation and more particularly of deposition show that the conditions were very quiet, and probably of long duration. In this connection it might also be well to remark that the very nearly equible temperature of the globe which allowed the same animals and plants to flourish on the equator and the Arctic zone at the same time, even as late as the Tertiary period, would also prevent the formation of oceanic currents on a magnitude equal to the present streams, but then as at present, winds acted in promoting such agencies. Another agent which has suggested itself is earthquake waves originating beneath the ocean. We know that the transporting power of water varies as the sixth power of the velocity, consequently if the velocity be increased ten times, the transporting power is increased 1,000,000 times. It has also been ascertained that water moving at the rate of three feet per second will carry angular stones the size of a hen's egg. What would be the result then of a wave 300 miles in diameter, and sixty feet high, moving at the rate of 370 miles per hour in its erosive action upon the adjacent coasts? One can readily conceive that it would be possible to carry boulders two feet in diameter a considerable distance, while the beds of conglomerates which exist in Scotland could be produced by this agency instead of the direct intervention of glacial action as Croll has supposed. We have good reason to believe that earthquake action was as frequent and extensive in the times under consideration as at present, and the great sea-wave just described, which took place during the South American earthquake in 1868, would probable be surpassed by those of previous epochs. Rivers also operated to a large extent, especially during the lower Carboniferous.

Among the elements necessary to the formation of sandstones, and as we shall also consider more particularly of conglomerates, are primarily the elevation of land areas above water as the Archaean rocks of Canada at the beginning of the Palaeozoic age, with other narrow ranges running southwestward parallel with the Atlantic, and still additional areas now represented by the Cordilleras. We have also to take into account that the amount of carbon dioxide in the atmos-

phere during early geological ages, exerted in connection with water a much more powerful and quickening effect in atmospheric and atmospheric-aqueous action, which must have greatly hastened the denuding action during Silurian, Devonian, and early Carboniferous ages, at the same time changing the chemical arrangement and physical form of the rocks. The lowest orders of plant and animal life also furnished contributions, which taken in connection with the large amount of organic material represented in some limestone formations, as for instance the Hudson group at Cincinnati Ohio, and the carbonaceous elements of many of the black shales constituting the Devonian and the relatively thin, but very important coal seams, clearly indicate the manifold operations of organic existence, as well as the inorganic. In addition to this, we have a counterpart to the formation of coral reefs at the present, duplicated to an unusual extent during the Niagara and lower Devonian, giving rise for example at Louisville, Ky., to a barrier which causes the falls of the Ohio.

An element involving both physical and organic connection is also paramount, as furnishing an index as to the position occupied by the Atlantic ocean. It seems quite apparent that since areas on both sides of its present basin have similarly equivalent, recurring faunas, often quite restricted as in the Cuboids zone, that it was influenced by physical environments which may have also operated in producing sediments for the adjacent coasts, but of this nothing can be said with certainty. Recent surveys have determined the position of three submerged mountain ranges running north and south in its central basin. It is certain that at least portions of the Mediterranean have been eroded to an enormous extent, producing material for the adjacent coasts. Before attempting to trace the origin of some of the sedimentary rocks subsequent to the Cambrian it will be necessary to determine the land areas existing in Ohio. That the Cincinnati geanticine existed at the close of the lower Silurian, forming an island in southwestern Ohio and the adjacent parts of Indiana and Kentucky, is indicated by the absence of upper Silurian and lower Devonian over that area, these formations being deposited on its margins northward. In Tennessee a hiatus is revealed on account of the Devonian black slate resting directly on Lower Silurian beds, clearly indicating the land ares during the upper Silurian and part of the Devonian. This land area had a great influence in building up the subsequent Palaeozoic rocks, as we shall see further on.

The fluctuations and arrangement accompaning the formation of the lower Helderberg strata in eastern New York, show that the upward movement begun there at the close of the Cambrian period, still further progressed after the deposition of the Hudson group, throwing the rocks of that formation above the level of the ocean into anticlinal and synclinal folds east of the Hudson, while decreasing in intensity westward. The Hudson formation may have furnished sediment from which the Oneida comglomerate was in part derived, but it is apparent that the later beds of the Niagara period had a connection with the vastly thicker formation in Canada through a channel possibly leading northeastward from western New York. With only a thickness of 300 to 400 feet in Ontario, increasing to 1,300 feet in Nova Scotia, it seems possible that the sediment was derived from regions north or northeast of New England, while the intimate relation of its fauna to that of England point to a very close biological relationship between the two areas, which oftentimes results from an uniformity of physical environments. The thinning out westward of the lower Helderberg group in New York, together with its comparative thinness in Tennessee, demonstrates it to be an essentially eastern formation. Unlike the Niagara, however, it thins out very rapidly to the westward until in Cayuga county it has almost entirely disappeared. It is obvious, however, to the most casual observer, that the Helderberg escarpment in Albany county must have had a much greater extension northward than at present, and after H. Fletcher's determination of the thickness in Nova Scotia (1,000 feet), we can probably admit the truth of Logan's determination that it was connected with the Canadian basin through the Champlain valley; bounded on the east and west by the folds of the Cambrian and the Adirondack range.

Continuing upward in the geological formations we find the Hamilton group with a thickness of 1,200 feet in the Catskill region, but rapidly thinning to the westward, until in western New York it is scarcely 200 feet thick, while at the falls of the Ohio the beds include 20 feet of impure limestone. In eastern Pennsylvania the greatest maximum thickness is 5000 feet, in the Gaspe region 6000 feet. The associations of the specimens I have seen from Perry (?) Maine would indicate an estuary connection with the Gaspe fauna, outside of the main line of deposition. The manner of preservation is very similar to specimens from western New York. It is impossible not to believe that the Hamilton strata did not extend farther eastward, northward,

and northwestward than at present, but all the strata have suffered denudation to an enormous extent, and we would not know of any northwestern connection, but for the Mackenzie river deposits. It is possible that portions of the Hamilton formation were derived from uplifted beds of the Hudson group and other formations east of the Hudson valley, and the Adirondacks may have contributed its share. It is obvious that the sediments could not have been derived from either the west or the southwest, and since according to Dana's determination the Champlain outlet was closed it is apparent from the relative thickness in the Catskill region, Pennsylvania and Nova Scotia, that the parent rocks may have been what is at present the bed of the western north Atlantic ocean, but it is entirely hypothetical. The lithological aspect of the formation is very suggestive as to its origin, especially when taken in connection with the organic remains. In eastern New York the strata are silicious with interspersed beds of shale, and containing land plants very similar to those described by Dawson from St. John. Lepidodendra as drift material, together with Psaronius actually growing and covered by the deposits. Farther westward the strata become thinner and more argillaceous, indicating quiet marine conditions, and greater distance from the source of the sediment. Certainly, however, there was an open connection with the eastern Canadian basin, by means of which an active inorganic and to a lesser extent faunal relation was sustained. It is also apparent that the strata in the Gaspe region were much nearer the original source of the sediment. I have rarely noticed very thin conglomerate beds in the Schoharie valley suggesting shore-line deposits—the precursors of greater strata which were deposited in the Chemung and Carboniferous strata.

Scarcely any subject in Palaeozoic stratigraphy with the exception of the Taconic question has caused more discussion than the relation of the Chemung, Catskill, and Waverly formations. Alexander Winchell would have had us believe that the Waverly and Catskill were in the same basin of deposition and coexistent. Another author contends, and very probably, that the Chemung and Catskill are equivalent formations with only a lithological difference due to different physical environments, while the Chenung and Portage are related but distinct formations. Prof. J. M. Clarke from palaeontological evidence links the Portage with the underlying beds. Prof. J. J. Stevensen on the other hand uses Chemung for a generic term with the divis-

ions Portage, Chemung and Catskill, and finds that the Catskill period presents a closely circumscribed area during the deposition of the last beds of the Chemung but was greatly enlarged to the southward during the formation of its upper beds. We incline to this opinion, at the same time correllating the Chemung of Brown county N. Y., with part of Mather's Catskill group of the Catskill mountains as Mr. N. H. Darton has done, leaving the Catskill group of Stevenson as a formation which had its greatest and typical development south of the Pennsylvania line, and outside of the typical locality which includes strata not understood when Mather made the survey of his district. It may be that the red Bedford shale lying at the base of the Waverly formation in Ohio represents a connection with the Catskill of the east about the latitude of Pittsburg, but it contains recurrent Hamilton species which lingered in the west long after the Hamilton formation was succeeded by later deposits in New York. The Bedford sea could probably be represented as an estuary in Ohio, which was bounded on the west by the fold of Cincinnati rocks and those of later age. The gradual uplifting of northern Ohio which had then begun, continued in operation until the following lower Carboniferous horizons were deposited on a shoreline which steadily progressed southward.

The Chemung group is 350 feet thick in southwesthern Virginia on the Tennessee line, but rapidly thickens northward, being 3800 feet thick on the boundary line between Virginia and Pennsylvania, 4700 feet in Huntington county Pennsylvania, and four thousand feet near the New York line on the Delaware river, while in the Catskill mountains it is 3000 feet thick. In southwestern New York the Chemung is 1200 feet thick. The Chemung strata thin out to the westward and south-westward in Pennsylvania, but northward along the western boundary line it reaches a thickness of 1400 feet in Crawford county near Lake Erie. The Erie shales which represent the western extension of the Chemung in Ohio rapidly thin out as we approach Columbus, almost, if not quite disappearing as we approach that city. Prof. E. Orton states its thickness at 300 feet, but it is very variable. When the stratigraphy is subject to so much variation in thickness, lithological appearance, and distribution, we must be prepared to be somewhat at variance concerning the origin of its individual beds of conglomerates, as well as the remaining strata. Prof. I. C. White has correllated the Panama with the Alegrippus conglomerate,

and likewise the Salamanca layer with the Lackawaxan pudding-stone, thus making the two layers continuous over southwestern New York, across eastern Pennsylvania on a line rudely parallel with the Blue ridge into southwestern Virginia. In the Catskill mountains a layer of conglomerate is present which may be equivalent to one of these layers. It seems quite natural that the conditions attending the formation of the Hamilton group again operated to a lesser extent during the upbuilding of the Neodevonian. It cannot be denied that the lower Chemung was restricted in its basin to the northward, while in its limited extension east of the Hudson the highlands of New England may have furnished material for its upbuilding. In Ohio rather abruptly limited on the west by the Cincinnati uplift, the strata were deposited in a sea whose main axis ran north and south, and which received its sediment from currents directed northward. It may possibly be that the hiatus existing in Virginia between the Archaean and Tertiary went to supply part of this material, while it is natural to conceive that strata now only represented by the West Indies may have not only sent its contribution to this formation but still others in the geological scale. But of that nothing can be said with certainty. The effect of tidal currents is essential in producing such beds of conglomerates as have been laid down during this age, and in the flat and round pebbles of the Panama and Salamanca conglomerates, we have illustrated the active erosive in shallow waters, with the result of somewhat different physical environments.

Although somewhat intimately related in the eastern extension of its basin with its underlying rocks the deposition of the Waverly shales in Ohio witnessed an important change in the physical geography of the lower Carboniferous formation. On the northwest there was a close connection with the Marshall group in Michigan, and even after the Berea and Cuyahoga shales had been uplifted in northeastern Ohio the channel remained open at least until the middle Waverly freestones had begun to be deposited farther south, probably receiving accessions for growth from the Cincinnati geanticline, but the physical conditions for faunal existence farther south toward the Ohio river were not favorable at the close of the lower first division of the Waverly. East and northeast from central Ohio, the conditions attending the deposition of the middle and upper Waverly were apparently more favorable under the coal bearing formations

south of lake Erie, and it is only in that way that we can account for the occurrence of conglomeritic beds and other higher horizons, which are not represented in northern Ohio, but which nevertheless reappear in Pennsylvania. To Prof. C. L. Herrick we are greatly indebted for the determination of the different zones of the Waverly, and more particularly of their faunal characteristics. The student desiring to obtain some conception of the evolution of biological forms from the Devonian to the Carboniferous, together with an exact idea of the stratigraphic relations in this formation, is referred to the Bulletins of the Scientific Laboratories of Denison University volumes III-V, and volume VII of the Ohio State Geol. Survey. While the increasing thickness of the upper Waverly formation toward southern Ohio points in that direction as from which sediments were borne, we are apparently confronted with the fact that the rivers which deposited the conglomerates came from the northeast. They differ from the beds forming the Chemung conglomerates in the comparative restriction of their areas and manner of deposition, but are so closely allied lithologically as to point towards a common source of origin. In the Waverly all that we know definitely of the upper conglomerate which may represent a repetition of the lower member is that it was deposited in the deepening sea near Portsmouth, Ohio, and along a north and south line east of Newark, through Mount Vernon, near Independence which is about twelve miles southeast of Mansfield, where it was at one time confused with the Carboniferous conglomerate 150 feet higher, and having on both its east and west sides broad and gradually decreasing deposits. A section at a right angle to this line of deposits at Lyon's falls near Independence shows a layer forty feet thick thinning out very rapidly east and west. At the "Back bone" one mile east it is only two feet thick, while it entirely thins out westward. It disappears under the coal measures northeast of Wooster, and we are left to speculate as to its further course, and origin. It may be that some of the sub Olean conglomerates in northwestern Pennsylvania belong to the same horizons, but this remains to be verified.

The beds of sandstone overlying conglomerate II near Black Hand occasionally contain pieces of chert, which is characteristic of the St. Louis formation at New Providence Indiana. It is very suggestive as showing the direction taken by some of the currents which deposited the upper Waverly, besides furnishing an index as to the age

of those sandstone beds underlying the Chester or Maxville limestone.

The great salient features concerned in the growth of the American continent are represented by the Archean nucleus with its essential importance in building up strata and protecting the life of the seas washing its shores; the Cincinnati geanticline further modifying and hastening the processes long since inaugurated, and forming a basin which exerted a profound influence not only physically but biologically; and finally the Appalachian revolution which terminated to a great extent courses which had long been in operation for the preparation of the world for the coming of man, but which, nevertheless, made tangible the physical environments necessary for the higher existence.

II.

LICHENS OF LICKING COUNTY, OHIO.

J. ORRIN R. FISHER, M.S.

The following list is intended to include such lichens as have been found in this county, and worked up by the author during the school year of 1893-94 in the Denison University laboratories. To this list have been added a few specimens from the neighboring county of Muskingum; the localities given being followed by "L." for the former, and by "M." for the latter county.

The names and authorities are given in conformity with Tuckerman's "Synopsis of the North American Lichens," and most of the identifications have been confirmed by other investigators.

In this list are at least four specimens not before reported for the State, viz:

Cladonia symphycarpa Fr.;

Lecanora cenisia Ach.;

Pannaria nigra (Huds.) Nyl.;

Peltigera canina (L.) Hoffm., var. spongiosa Tuckerm.

As to collecting it is difficult to say where are the best localities, for all are good; but a trip to Black Hand for crustaceous and rock lichens, to Buckeye Lake or Munson's Hill for fruticulose lichens, and to the region around Newark or to Pleasant Valley for foliaceous ones, will reward the collector with many fine specimens.

The study of lichens is an interesting one, and offers to the diligent and careful student a rare field for investigation from the fact that there are many points yet to be determined in their structure, and very many specimens yet to be classified and named.

The following lines quoted by Henry Willey in his "Introduction to the Study of Lichens," represents the attractiveness of the study:

"If I could put my woods in song,
And tell what's there enjoyed,
All men would to my garden throng,
And leave the cities void.

In my plot no tulips blow;
    Snow-loving pines and oaks instead;
And rank the savage maples grow,
    From Spring's first flush to Autumn red.
My Garden is a forest ledge,
    Which older forests bound."

* * * * * * *

"Wings of what wind the Lichen bore,
Wafting the puny seeds of power,
Which, lodged in rock, the rock abrade?"

LICHENES.

Tribe I. PARMELIACEI.

Ramalina, Ach., DeNot.

R. calicaris, (L.) Fr., var. fastigiata, Fr. Granville, L., and Adamsville, M. Occurs on trees, &c., in moist localities.

Usnea, (Dill.) Ach.

U. barbata (L.) Fr., var. florida Fr. Buckeye Lake, L., Adamsville, M. On trees and dead wood, abundant.

Theloschistes, Norm. Emend.

T. concolor (Dicks) Tuckerm. Granville, L. Common on trees and rocks.

Parmelia, Ach., DeNot.

P. borreri Turn., var. rudecta Tuckerm. Granville, Buckeye Lake, L.

P. cetata Ach. N. E. of Granville, L.

Physcia (DC., Fr.) Th. Fr.

P. speciosa (Wulf., Ach.) Nyl. Fair grounds, Newark, L. On trees.

P. hypoleuca (Muhl.) Tuckerm. Spring Valley, Granville, L.

P. leucomela (L.) Michx. Buckeye Lake, L.

P. aquila (Ach.) Nyl., var. detonsa Tuckerm. Toboso, or Black Hand, L.

P. stellaris (L.) Tuckerm. Granville, L.

P. tribacia (Ach.) Tuck. herb. On Newark Fair Ground, and near Haven's Quarry, S. of Newark, L.

P. HISPIDA (Schreb., Fr.) Tuck. herb. On branches in N. side of Cranberry Marsh, Buckeye Lake, L.

STICTA (Schreb.) Fr.

S. AMPLISSIMA (Scop.) Mass. Granville, L, Abundant.

S. PULMONARIA (L.) Ach. Common in Licking county, but none found with apothecia. A specimen collected in a strip of dry woods one mile N. of Sonora, Muskingum county, exhibited apothecia containing the typical cymbiform spores.

PELTIGERA (Willd, Hoffm.) Fée.

P. HORIZONTALIS (L.) Hoffm. Munson's Hill near Granville, L., on the earth; near Adamsville, M., on mossy rock.

P. RUFESCENS (Neck.) Hoffm. Toboso, L. Under a rock ledge.

P. CANINA (L.) Hoffm., var., SPONGIOSA. Tuckerm. Granville, L.; Pleasant Valley, M. On the earth and dead-wood.

PANNARIA, Delis.

P. NIGRA (Huds.) Nyl. Toboso, L.; Pleasant Valley, M. On large sandstone rock.

PLACODIUM (DC.) Naeg. & Hepp.

P. FERRUGINEUM (Huds.) Hepp. Very abundant on small stones in the vicinity of Granville, L.

P. FERRUGINEUM (Huds.) Hepp., var. DISCOLOR Willey in Litt. Granville, L.

LECANORA Ach., Tuckerm.

L. CENISIA Ach. Granville, L.

L. SUBFUSCA (L.) Ach. Granville, L. on wood and rocks.

L. VARIA (Ehrh.) Nyl. Granville, Buckeye Lake, L.; Pleasant Valley, M. On trees, well distributed in both counties.

RINODINA Mass., Stizenb., Tuckerm.

R. SOPHODES (Ach.) Nyl, var. EXIGUA Fr. Pleasant Valley, M., on bark of trees.

TRIBE II. LECIDEACEI.

CLADONIA Hoffm.

C. SYMPHYCARPA Fr. Granville, L., Zanesville, M., on the earth abundant.

C. MITRULA Tuckerm. Granville, L.

C. PYXIDATA (L.) Fr. Granville, L.

C. FIMBRIATA (L.) Fr. Granville, L.

C. GRACILIS (L.) Nyl., var. VERTICILLATA Fr. Munson's Hill near Granville, L.

C. SQUAMOSA Hoffm. Granville, L.

C. DELICATA (Ehrh.) Fl. Granville, L., Zanesville, M.

C. FURCATA (Huds.) Hepp., var. CRISPATA Fl. Granville, L.

C. RANGIFERINA (L.) Hoffm. Toboso, L., on the earth upon Black Hand Rock.

C. RANGIFERINA (L.) Hoffm., var. ALPESTRIS L. Locality same as preceding.

C. CRISTATELLA Tuckerm. Granville, L.

C. UNCIALIS (L.) Fr. Toboso, L. on Black Hand rock.

C. CÆSPITICIA (Pers.) Fl. Nashport, M.

C. RAVENELII Tuck. "Alligator Hill" near Granville, L. on board fence.

BEOMYCES Pers., DC.

B. ROSEUS Pers. Toboso, L. on the earth upon Black Hand rock. Rare, having been found in no other locality.

LECIDEA (Ach.) Fr. Tuckerm.

L. ALBOCÆRULESCENS (Wulf.) Schaer. Toboso, L.

L. PLATYCARPA Ach. Toboso, L.

BUELLIA DeNot., Tuckerm.

B. PARASEMA (Ach.) Th. F. Pleasant Valley, M. on trees.

B. PETRÆA (Flot., Koerb.) Tuckerm. Granville, L.

TRIBE III. GRAPHIDACEI.

GRAPHIS Ach., Nyl.

G. SCRIPTA (L.) Ach. Granville, L. abundant on dead wood.

TRIBE V. VERRUCARIACEI.

VERRUCARIA (Pers.) Tuck.

V. RUPESTRIS Schrad. Fultonham, M.

PYRENULA Ach.

P. NITIDA Ach. Granville, L.

III.

A CONTRIBUTION TO THE KNOWLEDGE OF THE PRE-GLACIAL DRAINAGE OF OHIO.

PART II.

PRE-GLACIAL AND RECENT DRAINAGE CHANNELS IN ROSS COUNTY, OHIO.

By GERARD FOWKE.

Ross county presents an interesting field for the student of glacial geology.

The southern limit of the ice-sheet is marked by a well-defined terminal moraine which follows almost exactly the diagonal of the county, as it enters at the northeast corner near Adelphi and passes out about two miles beyond Bainbridge at the junction of Ross, Pike, and Highland counties. There are few points along this line where the drift is not a prominent feature of the landscape; in many places it has a thickness of more than 100 feet exposed and occasionally attains an elevation of about 150 feet above the streams which flow across it or along its margin. Some very large "kettle-holes" exist on this border; while numerous sections along the nearly vertical banks of streams or in excavations for ballast or pike material afford excellent opportunities for observing the complicated structure produced both by the ice itself and by currents from its melting. These features, however, except perhaps as to the thickness of the deposits, are common in all glaciated regions and may be as well studied elsewhere; but there are few, if any, places where in an equal area may be found so great an alteration in water courses as has taken place in the southwestern quarter of this county since it was first invaded by the glacier.

By reference to the map (Plate I), it will be seen that, at present, Paint creek forms the western boundary of the county from Greenfield to the mouth of Rocky Fork, near the point marked *H*. Thence it flows nearly east for about three miles, after which its general direction is northeast to the point *E*. Here it bends abruptly to

the southeast, then toward the northeast to the point *C*, from which its general course is east to the Scioto river. Somewhat more than two miles above Rocky Fork, a considerable tributary, Rattlesnake Creek, or Rattlesnake Fork, enters ; and the enlarged stream pursues a tortuous course of several miles to *H*. At the point *G* is a ledge of limestone, forming the Falls of Paint Creek. The largest tributary within Ross county is North Fork whose head-springs are on or beyond the Fayette county line; it flows southeast past Frankfort and enters the main stream at *C*. There are many smaller streams, and scores of ravines, some of them several miles in length; but only those are represented which contain water all the year. The lowest level at which the bed-rock is visible, whether in the bed of streams or on its line of contact with the drift, is shown by heavy dotted lines; no account is taken of the superficial deposit on the table lands, which in most places is quite thin and frequently is altogether lacking. In the low-lands the drift extends to a greater depth than has ever been reached by well diggers. The crossed lines denote drift-filled valleys in which there is now no running water in greater amount than may come from a small spring.

A tour of discovery by a person unfamiliar with the country, starting at Greenfield to follow the course of Paint Creek, would, to judge from the experience of the writer, result somewhat in this way, except that a large part of the territory here figured would have to be closely and accurately examined many times before the facts were understood :

From Greenfield southward the investigator will find limestone cliffs bordering the stream, separating here and there with little level valleys between them, the water skirting the rock along first one side and then the other. Tributary ravines, dry most of the year, show similar gorges or canons. When he reaches Rattlesnake he finds the valley swing east and widen considerably, with heavier deposits of drift ; but suddenly it turns southward again through a valley more contracted, with rocky walls. Following these, he presently turns northward, and finds drift deposits on both sides of him. These, however, soon disappear, and he follows a long loop through bed-rock, coming after awhile to a place where the stream again flows through drift almost to the mouth of Rocky Fork. From here, for several hundred yards (at *H*) the bottom of the creek is solid rock, with thousands of "pot-holes" and long narrow grooves cut by the stones

and sand whirled along by the rushing water which in the last 200 yards of this rocky bed has a fall of 19 feet. Suddenly the turbulent stream comes to rest in a quiet pool which has a depth near its upper edge of about 80 feet. The right bank continues its course as an unbroken bluff; but the left bank abruptly terminates with a sharp anvil-like point projecting into the deep water. On crossing over, it is seen that the upper edge of the pool, on the northern side, is some distance above this point, with a muddy shore in which no limestone is apparent. This shore gradually curves around toward the east until it forms a bank to the creek parallel to that on the south side. Climbing the gravel hills to a point north of *H*, the traveler sees to the westward conical and roof-like hills, whose smooth-flowing outlines show them to be of drift material, stretching away to the bend just below Rattlesnake which he had left some hours before; and he further sees that they appear to cross at the points where he had lost the limestone on his way down. Thorough examination, involving many miles of tramping to and fro, convinces him that Rattlesnake is flowing in a pre-glacial valley which was filled with drift from the junction of Paint creek to this deep pool at Rapids Forge *H*; and that after seeking outlets in various directions as shown by abandoned channels and minor terraces it finally escaped along its present crooked way, regaining its former bed by cutting out the limestone which had made its southern boundary, washing down-stream the gravel that it found filling the present pool and making with it a dam which retains the water. He finds also, that the beds of both Rocky Fork and that portion of Paint creek above the mouth of Rattlesnake have been eroded in post-glacial times.

Somewhat more than a mile below the pool at Rapids Forge, the rugged hills on the south cease and in their stead appear conical knolls which cause the observer to rub his eyes and wonder if he has been suddenly transported to the region of Omaha; for at no nearer point will he find such remarkable resemblance to the Missouri river bluffs. Next, he sees a valley opening from the south, and then reappear the hills capped with Waverly sandstone such as he had seen above; but they are farther away from him. Following the road along the creek bank he soon approaches their foot; and now the hills on the north side have receded, while the creek, making a salient angle, seems bent on following them. Leaving the road, which continues in nearly a straight course and following the creek to the Falls *G*, he finds a

cataract 8 feet high pouring over the last exposure of limestone in the valley, the bed rock from here to the Scioto being shale. In the bottom land, just east of the falls, is a very large gravel deposit, part of the old moraine, with lower ground between it and the hills to the southward. It is apparent that at a comparatively recent date the creek has flowed through, or south of, the site of Bainbridge. More time is required for one fully to realize that he has followed thus far what was once only a tributary to a far larger stream; that Rattlesnake formerly had its mouth just above the Falls; and that only now has he reached the true valley of Paint creek. But the sudden widening from a few hundred feet to nearly a mile; the break in the hills to the southward, filled with gravel-knolls over 150 feet high; the persistence of this gravel up to Beech Flats with rock-capped hills on either side; the width of the valley, almost as great at the Falls as at any point below;—all are proof that the headwaters of Paint must be sought to the southwest, possibly as far away as Brown or even Clermont county, for all the streams rising in the area which may formerly have been drained by this lost part of Paint creek flow southward or westward through gorges or narrow troughs in their whole course, none having the broad valley so characteristic of this. Mr. H. W. Overman, of Waverly, pointed out years ago that the drainage of Ohio Brush creek was reversed, its natural course being to the north instead of to the south. The same will probably be found true of other streams still more to the west.

Leaving this for future determination, our student goes on down the broadened valley, admiring the wonderful fertility of the soil, the fine farms, the picturesque beauty of the sloping or, sometimes, precipitous hills that border it. Perhaps he turns aside at *F* to examine the vertical exposure of nearly 300 feet of shale at Copperas mountain into whose base the creek has cut its way; he notices a dark line near the top which marks the separation between the Devonian and the Subcarboniferous. Similar, but much smaller, sections may be found at other places where the creek cuts against one hill or the other as it swings back and forth across the intervening space. Not far below *F* is a fine vertical exposure of gravel capped with clay and sand, in all about 60 feet; the bank is rapidly caving and is now several yards within the original line of the pike which has been twice moved back. Finally the creek, skirting along the southern range of hills, is lost to sight for about three miles and is next seen at Slate

Mills. But instead of flowing on gravel as heretofore, it is on a bottom, and between banks, of bedded shale, with gravel on the farther side above the shale. While the traveler is pondering over this, he suddenly observes that it is flowing to the right, as it did when he crossed it before, two miles below Bainbridge; and he knows he has not crossed it twice. He looks on, in the direction toward which he is traveling, and sees the same range of hills on either side bordering a drift-filled valley such as he has been coming along for several miles; but he is now looking *up* the stream instead of *down* it. More puzzled than ever he leaves the pike and follows the stream which soon curves around to the westward. He thinks this is as it should be until he unexpectedly finds himself on a railway which he does not remember to have seen; true there was a railway near Bainbridge, but he knows he is not back there; besides it is not going in the same direction. Presently he sees another railway; both of them, with the creek, disappear in a narrow gorge which he certainly has not seen before. Next, he notices that the stream is not more than one-fourth as large as it should be. Wondering if he is bewitched, he climbs a hill, looks to the westward, recognizes numerous places he has passed; looks eastward and sees the continuation of the valley, but without a sign of water in it. He tries to trace the stream he has just left; it passes the bridge where he first saw it, wanders through a narrow valley, runs up to a high hill, and apparently stops there. He then walks south across fields, thinking thus to reach the larger stream, and finds himself at the bridge again. He inquires at the mill near by as to the location of Paint creek, and is told with a vague general flourish of the hand in the direction of the setting sun, that it is "up that way." Retracing his steps for weary miles, he finds his lost stream half-way back to Bourneville. Determined not to lose it again, he notes the trend of the current, starts in the same direction closely watching the hills to the south, and is satisfied there is no place it can pass through. He can not *see* the stream, but he knows it runs along the foot of the hill under those huge elms and sycamores. Soon he finds himself at the foot of the hill near *D*; but there is no creek visible—the gravel is piled up against the slope. Uncertain whether to swear or to pray, he walks on and reaches the mill, whose owner eyes him suspiciously. Making further inquiries, he learns that the bridge is over North Fork, which flows into Paint creek about two miles from where he stands. Taking the new direction to the

southward, he finds Paint creek again at *C*, and follows it thence through a broad valley to the Scioto bottoms. Coming back to *C* and ascending Paint creek he observes that the hills on either side contract in a V shape toward the mouth of Ralston's run, which runs through a level bottom about 500 feet wide with steep hills on either side. From here up to a ravine putting in from the west, there is a strip of bottom land on one side of Paint creek, nowhere wider than 400 feet; and from this ravine up to the point *E* the hills ascend from the edge of the water which flows on solid rock all the way. At *E* he finds the creek in its proper channel at the foot of the hill, under the elms and sycamores, just as he had thought when looking from the pike.

The order of events that gave rise to these conditions is apparently about as follows:

It is plain that the glacier reached, as a mass, to the old valley of Paint creek and that it did not ascend the hills on the southern slope or even reach to them anywhere below the point *F*, except at the points *B* and *D*. About two miles below Bainbridge, the drift is piled half-way to the tops of the hills to the south, and the valley along here must, for a time, have been entirely closed by ice. There is no doubt that it thus followed the valley nearly or quite to its head, leaving the deposits above Bainbridge, probably forming the Beech Flats, and filling up all the valleys when it passed out upon the limestone table-land beyond the rugged hills of shale and sandstone; thus deflecting toward the Ohio all the waters which in this region had flowed into Paint creek. But, as above stated, this is still to be worked out. At the point *B* where the creek formerly discharged into the Scioto the drift is fully 100 feet higher than the highest river terrace; the distance between the hills, measured on the drift, is a little less than one mile. The flat-topped hills at this place are about 100 feet higher than the drift. This denotes a sufficient thickness of ice to dam Paint creek and form in its basin a lake which, fed by the natural drainage and the floods from the melting ice would rapidly rise until it found a new outlet.

The Scioto having a deep pre-glacial channel, it is very probable that a lobe closed up the mouth of the creek at *B* some time before the main body of ice surmounted the hill and filled its bed. Between Slate Mills and the point *C* there was evidently a low depression formed by two ravines, one opening north into Paint valley, the

other south into Ralston's run (which then extended to the Scioto river, the creek having usurped its ancient channel) with a low divide between them. At its narrowest point this is now about 1000 feet wide. It is evident at a glance that Paint creek should have turned this way on abandoning its old channel; for this pass, as shown by its width, was much lower than any other that existed anywhere along the southern border. In fact, the stream must have gone through this way for a long time, and with a great volume of water, for it is impossible that so wide a valley could ever have been formed by natural erosion in so short a distance. Thus the whole drainage of Paint creek, reinforced by that from the glacier, would escape through this depression into Ralston's run at a level sufficiently above the Scioto to create a swift current, cutting both the depression and the run wider and perhaps deeper. When the glacier reached its ultimate extension, as a body, within the limits of Ross county, a spur reached entirely across the valley at the point *D* where the drift is piled to a height of about 120 feet above the present level of the creek. This was from a solid extension and not from a floating berg, because it is pushed up to this level over the solid rock. It would, consequently, shut off the former outlet and form from *D* southwestward a lake which rose until it began to flow over a col or saddle-back at the point *E* into a ravine, tributary to Ralston's run, which had worked its way back until it had to some extent lowered the crest in this range of hills; there was no corresponding ravine on the northern side. The cap rock is Waverly sandstone, full of joints; the underlying shale is so loose it can easily be dug out with a pick. When into such material a lake abundantly fed plunges from a height considerably greater than Niagara, the incoherent rock would disappear almost like wax before fire. If the present Ohio was closed at this time, the Scioto was a lake; if the former was open, the latter was a surcharged torrent.* In either case, it was backed up against these hills, forming a body of dead water in which all the rock eroded from the new gorge, along with such material as could be carried by ice, found a resting place, and settled on the drift that had been carried into the same backwater when the larger creek came down from Slate

*Since the above was put in type investigations in another direction have shown that the flood-height of the Scioto, immediately below Chillicothe, was at least 200 feet above its present bottom.

Mills. This we know, because an area of fully a square mile about *C* has a solid deposit of drift-material rising more than 100 feet above the creek, composed largely of sandstone blocks whose angles are scarcely worn, and masses of shale sometimes containing two or three cubic feet, which disintegrate after a few weeks of exposure to the weather. These could have come only from the gorge between *E* and the present mouth of Ralston's run. They are intermingled with sand and northern rock, promiscuously for the most part, but occasionally with a rude stratification as if the floods had been somewhat intermittent. The great apparent width of the valley below this point is due mainly to the filling-in by drift; but, it may be in part, also, to the earlier discharge of Paint creek having enlarged it to some degree, as mentioned above. The fall of ravines and minor streams outside the glaciated area is rapid; and in those filled with drift the depth to bed rock may be roughly estimated by carrying downward the line of slope of the hills on either side to their point of intersection. So of the larger streams. This statement, of course, does not hold good near the junction of two streams; when they have cut down to the level of those into which they flow, smaller streams can not further deepen their beds, but will swing from side to side thus making narrow bottoms. This is why there is always a widening of the valley where two branches unite; and in such cases the rule just given will not apply.

* * *

From the northwestern point of the hill southeast of Frankfort, one looks to the horizon northward over a practically level drift covered country. The hill on which he stands bears, on one hand north of east to the Scioto bottoms: on the other, it reaches a short distance southward, bends toward the west, and finally sweeps away northwest until it is lost to sight. This hill-land and the portion of the plain adjacent to it are drained by North Fork; the part north and east of Frankfort is drained by Deer creek. Both are of post-glacial date. The latter, being entirely superficial as regards the drift, need not be considered: the former has a history.

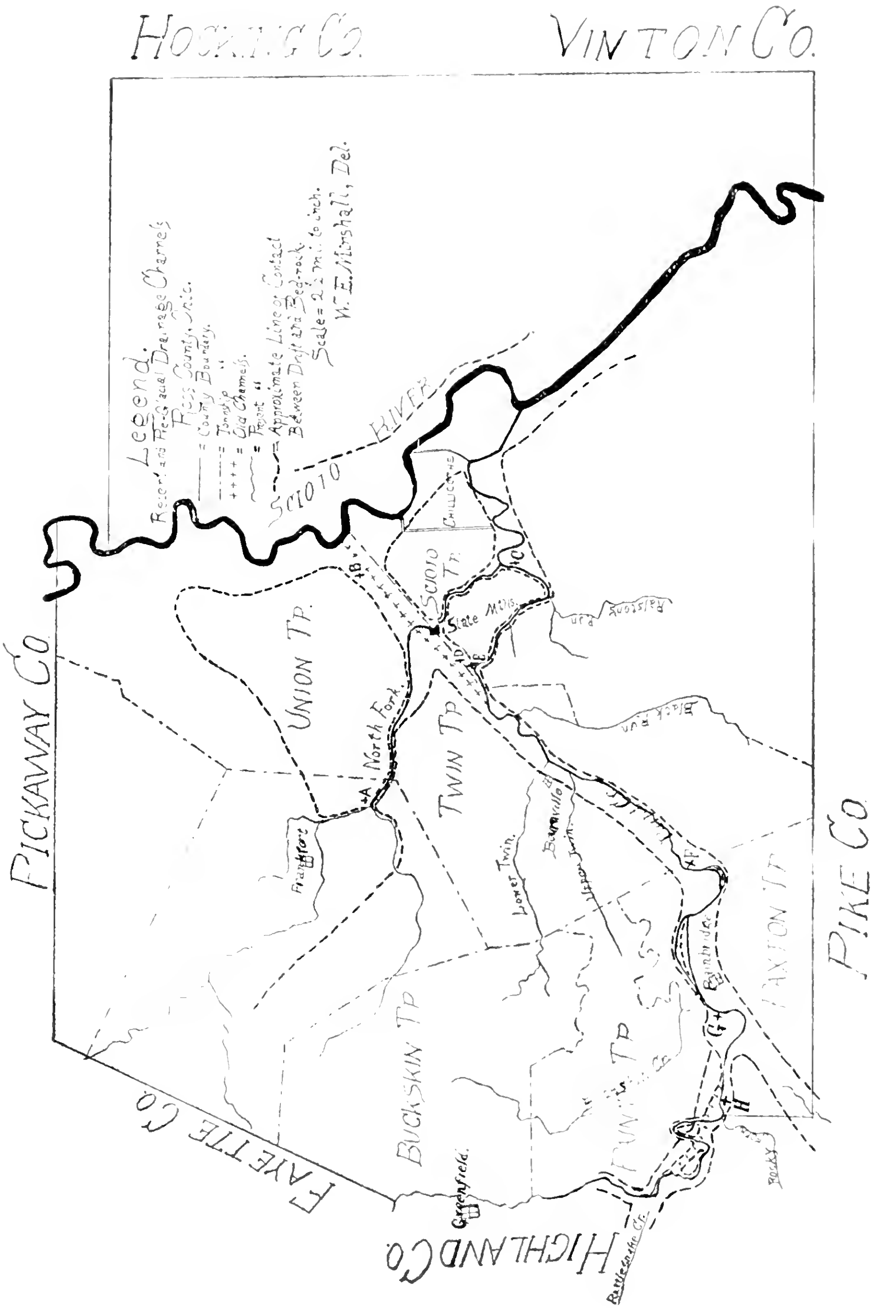
Prior to the advent of the ice, that part of the present valley of North Fork between Frankfort and Paint creek was a depression with an outlet in each direction, the dividing point between the two ravines being near where Union and Twin townships corner. At this point the shale hills are now less than 100 yards apart; just below (south)

they separate considerably, apparently planed out by the ice, and there are drift deposits more than 100 feet high through which the creek now cuts its way. These may have been formed by the advancing ice pushing through the valley a little ahead of that on either side which had to ascend the hills; or they may have been left on its retreat: or it is possible, though scarcely probable, they mark a re-entrant angle of the moraine. It is true there is a wide gap in the heavy deposits in the main stream below here, but it is more reasonable to suppose that they have been removed by erosion than to believe the ice-sheet would stop moving in a place so favorable to its progress. At any rate, a lake of considerable depth was at one time held back above them; for at the point *A.* on the hill-side, 75 feet above the railway, is a finely stratified deposit of sand. This, however, may have settled in the water which rose in front of the ravine (which then extended much farther to the north,) until it broke over the divide. When this happened, such water as went out this ravine became a part of Paint lake until the extension of the ice confined the latter above the point *D.* But between *B* and *D* there would still result from the melting ice a great quantity of water whose most natural, and indeed only means of escape until new channels were opened miles to the northward, would be toward *C* along the bed from which Paint creek had been so summarily shut off. This continued until the present course had been cut to a depth lower than the surface toward the east or west; and North Fork, being thus debarred from following the old valley in either direction, has ever since flowed directly across it, high above the original bed, as though carried on an aqueduct.

NOTE.—Too late to add to above paper, I discovered a glacial outlet in the eastern part of Ross county. A number of ravines from the hills back of Mount Logan and Rocky Knob, united and flowing past Mooresville or Halltown, discharged into the Scioto about four miles below Chillicothe. A smaller ravine skirted the northern slope of Rattlesnake Knob, and entered the river not far below the other.

With the greatest extent of the glacier, a lake was formed between its front and the hills a short distance west of Adelphi, over what is now known as Maple Swamp. This finally broke over into the first ravine mentioned, making a narrow gorge in the hills; at the

lower end of this there are drift-hills whose summits are at least 150 feet above Walnut Creek which now flows between them and the hills to the east. These deposits, extending for miles, and uniting with those made by the huge eddy formed by Mount Logan (which forced the glacial currents in the Scioto to the western hills), completely shut off these two pre-glacial ravines, and forced the water coming through the Maple Swamp gorge to skirt the hills, overflow the col back of Rattlesnake Knob, and sever that peak entirely from the range of which it formed a part. Through the narrow gorge thus made, Walnut Creek finds its way, and reaches the river miles below.



Hocking Co.
Vinton Co.
Pickaway Co.
Pike Co.
Fayette Co.
Highland Co.
Legend.
Recent and Pre-glacial Drainage Channels
Ross County, Ohio.
= County Boundary.
= Township "
++++ = Old Channels.
= Present "
= Approximate Line of Contact Between Drift and Bed-rock.
Scale = 2½ mi. to inch.
W. E. Marshall, Del.
Scioto River
Union Tp.
Scioto Tp.
Twin Tp.
Buckskin Tp.
Paxton Tp.
Chillicothe
State Mills
North Fork
Frankfort
Bourneville
Bainbridge
Greenfield
Lower Twin
Black Run
Ralstons Run
Rattlesnake Cr.
Rocky

PART III.

A Preglacial Tributary to Paint Creek and its Relation to the Beech Flats of Pike County, Ohio.

By W. G. Tight.

Reference is made in the preceding article, in this volume, on "The Pre-glacial and Recent Drainage Channels of Ross county, Ohio," on page 17, to the extension of the preglacial valley of the upper part of Paint creek to the southwest, at a point a little above Bainbridge. It was with a view to ascertain the course of this tributary to Paint creek that these studies were undertaken.

The results of glacial action along the margin of the ice sheet are so varied and at times so unexpected that almost every acre presents some new and interesting features. This region, lying as it does just on the boundary line of greatest glacial extention, is no exception. While it presents some characters common to some other localities studied, yet there are many new features which add especial interest to this field. A very casual observation revealed the fact that this preglacial channel extends to the Beech Flats of Pike county and is in some way connected with their origin. A view from one of the high Waverly hills at the junction of this valley with Paint creek would easily lead one to the conclusions stated by the author of the preceding article on page 18.

So striking are the topographical features of this region that we find them mentioned in the earliest writings on geology of this portion of the state. Dr. Edward Orton in his "Report on the Geology of Pike County" in the "Geological Survey of Ohio," Vol. II, 1874, makes the following statement with reference to this locality: "In the extreme northwestern . . . corner of the county, near Cynthiana . . ., there is a conspicuous example of surface erosion that does not belong to either of the systems thus far named, but which is

connected with the drainage systems of adjoining counties. The case is not explicable by existing agents of erosion. . . . The drift in the vicinty of Cynthiana often exceeds fifty feet in depth, and the origin of the great excavation which has here been effected must be sought in the glacial epoch, or in preglacial times."

Dr. G. Frederick Wright, in a number of articles published at various times, makes mention of the Beech Flats and the surrounding topography. In his recent work "The Ice Age of North America," 1891, on page 333, he gives a map showing the relation of the Flats and the head waters of Baker's Fork of Brush creek to the surrounding drainage systems, and makes some generalizations, based upon the Flats and certain features of Brush creek, which bear upon the important theory of the "Ice Dam at Cincinnati." While the value of this theory is not brought in question here, yet our conclusions, with reference to the origin of the Flats, lead to the belief that this theory must rest on other proof than that furnished by this region.

It has been my privilege to visit this region on a number of occasions, and personal examination has been made of almost the entire area represented on the map, Plate II. This map is constructed from data obtained from the following: "Map of the Marietta and Cincinnati Railroad, prepared by M'Gee and Phillips, Geological Locations and Sections by Prof. E. B. Andrews"; "Highland County, Ohio," from "Ohio Geological Survey"; Report of 1870; "Map of Highland, Ross, and Pike Counties"; of the "Ohio Geological Survey" Vol. II; "Pike and Road Map of Adams, Brown, Butler, Clarke, Clermont, Clinton, Darke, Fayette, Franklin, Green, Hamilton, Highlands, Madison, Miami, Pickaway, Pike, Preble, Ross, Scioto, and Warren Counties", "Geological Map of Ohio by Edward Orton" to accompany Vol. VI, "Ohio Geological Survey"; "Geological Map of Ohio by Edward Orton" to accompany Vol. VII, 1894, of the "Ohio Geological Survey"; with others. The topographical characters indicated on the map have been as accurately located as possible by sketch maps and field notes. They were located on the sketch maps in the field work, in relation to the pikes and roads, but it was not thought best to enter such details on this map as were not essential to the explanation of the work.

In order to get the facts presented in a connected manner, the reader is invited to accompany the author on an ideal trip of investigation, which is, however, with but one or two slight deviations, al-

most the exact duplicate of one of the trips taken during the study of the region. The line of this proposed trip is indicated on the map. (Plate II.)

Starting from Bainbridge, Ross county, our first point of observation will be the high quarry hill A just south of the town. This hill capped with Waverly freestone rises 450 feet above Paint creek, to an elevation 1180 feet A.T. A view to the north across the valley of Paint shows the hills forming the north wall of Paint valley over a mile away and rising nearly to a level with the observer. To the east extends the very deep and broad valley of Paint on its way to the Scioto. Large drift deposits fill the valley along its northern side, often rising to 150-200 feet above the creek. There are numerous terraces in the valley, and the creek is undoubtedly 150 feet above the rock floor of the valley. Westward the valley is distinguishable as a very evident trough of preglacial origin as far as the junction of Paint and Rocky Fork. Beyond rises very rapidly the drift-buried tableland of northern Highland county; and the well defined preglacial valley of Paint seems to end, suggesting some interesting problems in that direction, for somewhere in that locality we must look for the preglacial channel of reversed Brush creek.

As the view to the south is cut off by timber, we return to the pike and pass westward about one mile, where the view to the south shows a break in the high Waverly capped hills, and their place is taken by others of somewhat less altitude. From the pike along the creek the change in altitude would hardly be noticed; but as these hills are destitute of timber, they offer a prospect of an extended view to the south, and with this hope the ascent of the highest is undertaken. On reaching the summit at B, 190 feet above the river, and 990 feet A. T., it is found that this hill only concealed from the view on the pike still others just beyond, which rise just enough higher to obstruct the coveted view southward.

Our surprise is great, when almost on the summit of the next hill we find a ground-hog burrow, and the material revealed indicates glacial drift. The first thought is that this can not be drift at an elevation of 200 feet above the creek, and on the south side of Paint valley. A glance southward shows a comparatively level plain and not a rolling hill country as might have been expected.

This then is the extreme northern edge of the Beech Flats. What had concealed the real nature of these drift hills was their steep

slopes and sharp summits. It seems almost inconceivable that these till deposits could have retained such steep gradients for such a length of time, yet it is quite evident that the high angles are the original slopes of the moraine and are not due to the subsequent erosion. There are many deep gullies and ravines cut by present agencies which reveal the true till structure of the deposits, but these can be readily distinguished from the older forms, although in both cases the slopes are so great that it is almost impossible to climb them. The surface is sparsely strewn with erratics. One of fine grained trap was estimated to weigh a hundred tons. There was also found a jasper conglomerate about the size of a man's head. Many observations in the immediate vicinity of B gave a mean elevation of 200 feet above Paint creek, 1000 feet A. T. The maximum elevation recorded was 250 feet above Paint, 1050 feet A. T.

The most conspicuous object in view from B is a high treeless hill to the west, which is located on the Giffen farm and which I have called Peach Orchard hill. The eastern exposure of the hill is very steep, and is much cut up by gullies which show very beautifully the contact line between the drift and the rock soil. The thin covering of boulder clay is pushed up the side of the hill at least 70 feet above the mean level of the Flats.

From the top of the hill, C, the prospect is grand and is well worth the climb. At an elevation of 485 feet above the creek, 1285 A. T., with an unobstructed view in every direction, it can not but enthuse the observer. The topography is spread out for inspection like a huge relief map, which it really is. Northward the view is similar to that from A as is also the view to eastward,—with this difference, station A is over two miles away with a broad and deep valley intervening. Following with the eye the outlines of this valley, as indicated by the long lines of hills, it is seen to extend many miles to the south, and within its rock-bound walls 250 feet below lies a tract of country, the Beech Flats, which never seem so flat as when viewed from this elevation. To the west extends the long ridge of sandstone hills which form the south wall of Paint valley. Just south of this is another ridge running nearly parallel with it with quite a wide valley between. As it is not possible to determine all the characters of this valley and its westward extension, we descend into it and proceed westward along the dirt road which runs along its northern side.

At D a spur extends southward from the Paint creek ridge, and the valley is much narrower here. It again widens to the westward. The small stream which drains it flows along the southern side and reveals the rock for much of the way to Rocky Fork at Barrett's Mills. At this point the valley seems to end, with the western ends of the two parallel ridges standing out in bold relief, with no visible counterparts on the westward side of Rocky Fork, which has here cut its way through the drift and developed its deep and picturesque gorge in the limestone.

From Barrett's Mills the journey leads along the range of hills bordering Rocky Fork. This ridge is crossed with the expectation of gaining Brush creek valley.

At E a small stream is crossed which is flowing westward instead of southward. It is at once recognized as not being Brush creek, and so is examined more closely and is found to flow into Rocky Fork between two high sandstone hills and in a rock gorge with vertical walls. This gorge is 75—100 feet wide and is clearly seen to be deeply filled with drift. It is very apparent that the gorge is not the work of the present stream, but that the latter is running, at least at the upper end of the gorge, much above the rock at an elevation of 940 feet A. T.

The next objective point is F, a very high cleared hill south of the village of Carmel. This hill reaches an elevation of 360 feet above Carmel, which is given as 939 feet A. T. From F the view is as grand and extensive as from Peach Orchard hill at C. The points most interesting in this study are the broad valley extending to the northeast to Cynthiana and filled with an arm of the Flats, and another broad valley very similar to the last, but stretching off to the southeast. The view to the northeast reaches to the horizon along a continuous valley. The view along the valley to the southeast is terminated in five or six miles by a line of hills, which are later found to be the hills forming the eastern wall of the Brush creek valley.

After observing a few land marks that will aid the recognition of our point of view, we descend into the valley again and traverse its rolling surface to Cynthiana. Here the drift shows a mean elevation of 200 feet above Paint creek, 1000 feet, A. T. Ascending a hill, G, just south of the village, our landmark at C is easily located, and it at once becomes evident that the axis of the valley, observed from C, passes east of Cynthiana and farther to the southwest.

Following along this valley, with its drift surface much cut up into hills and valleys (yet when on top of the hills this surface appears quite even) we reach a point H, near a large iron bridge across Brush creek, on the pike from Sinking Springs to Carmel. Here is observed a side valley entering from the northwest. Crossing the bridge and proceeding along the pike to a high hill of till at I, 191 feet above Paint creek, 85 feet above the water in Brush creek at the bridge, the landmarks at F are visible, and then is understood the reason why this valley when viewed from F, appeared to be closed at its southeastern end.

As we pass down the valley of Brush creek, it is noticed that while the creek is running in a large valley in the drift-filling it is nevertheless flowing with a very sluggish current. The high sandstone and slate hills are closer together and the rock valley is much narrowed. One looks in vain for a gap in the hills which will indicate the position of the exit of the creek. The only apparent opening is in the direction from which we have come.

We proceed to K along the bed of the creek which now* contains no water, except in the deep holes and is a muddy and sandy channel. Here is a small stream entering from the western continuation of the old valley. Here also are found evidences of a buried rock ravine which occupies a position more central to the main part of the old valley. This old ravine is filled with till and its walls but thinly covered. Its position is shown by a meander of the channel of Brush creek and also by a side ravine of recent erosion, which crosses it. The small tributary to Brush creek is fed by a number of springs and flows along the contact line of the drift and rock, along the southern side of the old valley, its former ravine near the center of the valley being filled with the drift.

Standing at the mouth of this small stream, not 500 yards from the place where the channel of Brush creek is transformed into a narrow and deep gorge, one unfamiliar with the facts would find no marks to indicate the location of the exit of Brush creek from this apparent basin, so skillfully has nature concealed the facts by topographical features, and a luxuriant growth of underbrush along the stream, gradually merging into the forest of the mountains sides.

Shults' mountain, L, presents the most favorable opportunity for a comprehensive view. From its summit, 440 feet above the waters

*August, 1895; an extremely dry season.

of Brush creek and 1325 feet A. T., the broad plain of the Beech Flats stretches away to the northeast and the horizon is formed by the hills forming the north wall of Paint creek, opposite Bainbridge. To the north at the foot of the mountain, lies the short westward extension of this valley beyond the exit of Brush creek. In the distance are visible the tops of the numerous ridges shown on the map. The appearance being that of a very hilly country and also resembling the view to the east and southeast. So similar are these two views, that the conclusion is inevitable, that their topographical features are the results of similarly operating forces. The region to the east and southeast is beyond the limits of the ice and the natural inference is, that the region to the north has been so slightly modified, that the main features of its preglacial forms are preserved.

Fisher's mountain M stands out farther to the southwest, and its summit is reached at an elevation of 410 feet above Brush creek, 1295 A. T. To the south lies a broad expanse of low lying country in the vicinity of Sinking Springs. From this low region the general slope of the country rises rapidly across Adams county to and beyond the Ohio river. Into this inclined plain Brush creek has excavated a narrow and deep gorge. So narrow are the gorges of all the streams in this district that from the point of view chosen it is impossible to determine their courses. From this same depressed region the country level rapidly rises to the west to the water shed separating the waters of Brush creek and Rocky Fork from those of western Highland county. This region is sparsely covered with drift. The land also rises rapidly to the northwest to the table land and drift-covered region of northern Highland county.

The descent is now made in order to study the characters of the Brush creek gorge which lies,as shown from our maps, between Fisher's mountain and Fort Hill, but which was not visible from the summit of the mountain. After a very steep descent of 410 feet, the rough mountain road passes between two walls of limestone, evidently a great fissure, and emerges in the dry bed of Brush creek gorge. The slopes of Shults' and Fisher's mountains and Fort Hill have angles of about 35 degrees and where these plains of the mountain sides would intersect occurs the U shaped gorge of the creek, with vertical walls of about 50 feet and the gorge about 100-200 feet wide. The bed of the creek is composed largely of limestone gravel with a small percentage of northern drift pebbles. In no part of the gorge examined in this

cut between the mountains was bed rock shown in the channel. The conclusion is inevitable that the considerable volume of water in the creek above the gorge must find its way out through the gravel filling in the bed of the gorge. The gorge of this fork of Brush creek was examined at many points to the southward and everywhere was found a small percentage of northern pebbles. This would be expected as the head waters are in the great till deposits of Beech Flats.

An examination of the data obtained reveals the following relations. The Beech Flats is a large tract of level land lying at an elevation of 1000 feet A. T, and 200 feet above Paint creek, occupying a portion of the southwest corner of Ross county, a portion of the northwest corner of Pike county and a portion of the eastern edge of Highland county. This land consists of a great deposit of till, showing but a few slight marks of stratification, being in fact largely typical boulder clay. It is bounded on all sides, except at its northern edge, with high rock hills, capped with Waverly freestone which reach an average elevation of 1200 feet A. T. At its northern edge, where it borders the valley of Paint creek, is exhibited an average of 200 feet in the thickness of the deposit. This thickness decreases towards the south and southwest, due to a rise in the rock floor, while the top of the deposit remains at nearly the same level. The elevation of this surface is the same as that of the drift deposits on the north side of Paint valley and also of those to the west in the vicinity of Barrett's Mills and Carmel, both of which are beyond the ranges of hills enclosing the Flats. The surface of the Flats is much cut up into drainage channels, so that the roads and pikes which traverse it in every direction are by no means level, but on the other hand are quite hilly. These channels in many cases seem to be out of proportion to the streams that occupy them. The two principal ones being, the small stream that rises near Cynthiana and flows west into Rocky Fork, the other and larger being Baker's Fork of Brush creek, which also rises near Cynthiana and flows south past Fort Hill and Shults' mountain. In both cases the valleys these streams occupy in the drift seem too large to be easily accounted for by present forces, especially in view of the slight amount of change observed in the forms of the deposits next to Paint valley. Both these streams pass out of the district through rock gorges. The former at an elevation of 940 feet A. T. and the latter 885 feet A. T. In both cases also the gorges are now partially filled and the streams are not flowing through the gorges on rock floors. The former

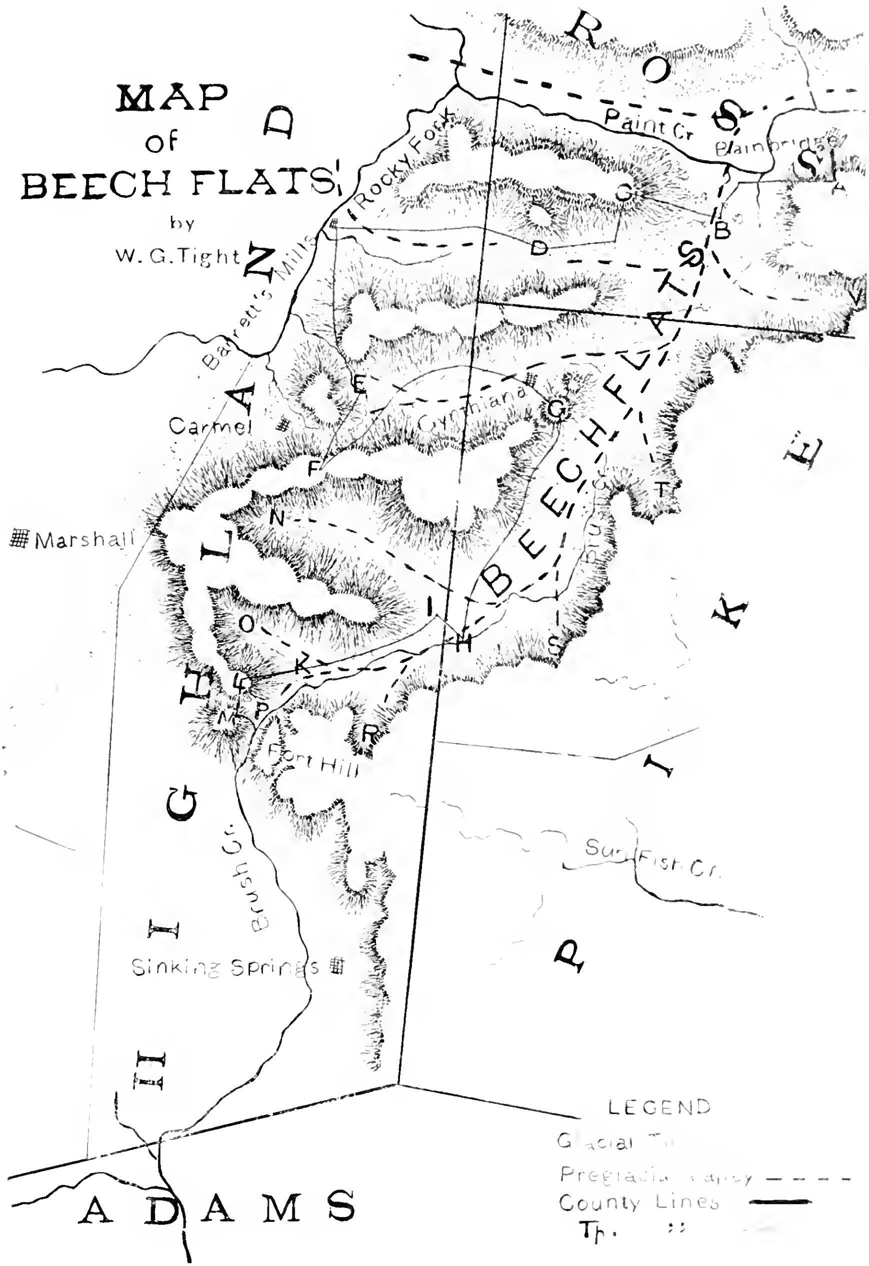
stream has a fall of about 75 feet in its source to its gorge, the latter, Brush creek, has a fall of about 121 feet from Cynthiana to its gorge. The gorge of the former at E is 140 feet above the base of the drift at Paint creek, and the gorge of Brush Creek is 85 feet above the base of the drift at Paint creek. If it were possible to remove the drift from these valleys it is evident that these streams would be reversed. The fact is more striking when it is remembered that the bottom of the drift at Paint creek is 150-200 feet above the preglacial bed of Paint valley.

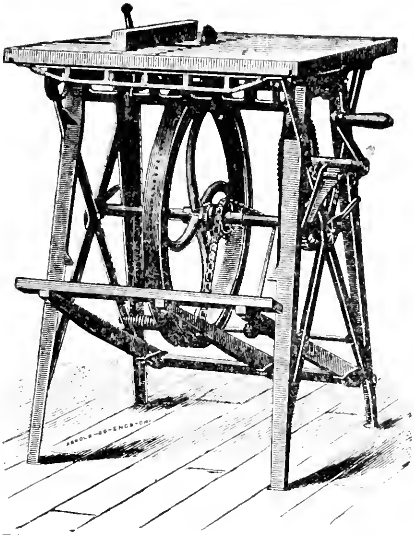
The conclusions which are drawn from the above facts are, that prior to the advent of the ice, the present location of Beech Flats was represented by a valley with numerous smaller tributary valleys, all tributary to the valley of Paint Creek. The heads of these valleys were at D, E, N, O, P, R, T, and V. At all of these points were cols connecting with adjacent drainage basins. As the ice advanced southward, planing and filling, it made the great drift plain of northern Ross and Highland counties and of Pickaway, Fayette, Franklin and Madison and other counties to the northward as its comparatively level ground moraine. It reached across the preglacial valley of Paint creek west of Bainbridge and pushed a great tongue of ice into Beech Flats valley. As this tongue advanced into this valley it divided again and again sending fingers along the tributary valleys clear to their head waters. Under these ice fingers was deposited the drift of the Beech Flats as a ground moraine. The spur which first separated from the main stream of ice crossed the col at D and probably joined the main mass of the ice sheet beyond Barrett's Mills. The next spur passes up the valley west of Cynthiana. The next spur passed up the next tributary valley to M. The main axis of movement continued beyond K to O, as shown by the till and boulders beyond the exit of Brush creek.

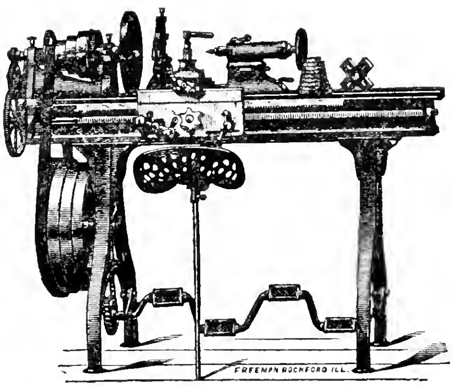
Large volumes of water were formed from the melting of these ice masses, for however much of rigor is attributed to the climate of the glacial period to account for the ice age, yet it seems evident that the margin of the ice extended beyond the line of perpetual snow and mean annual temperature of 32° F. into a temperate climate. The limit of the extent of the ice was determined by its rate of marginal melting as opposed to its rate of flow and supply of material by precipitation. The waters formed in the Beech Flats valleys found two outlets. One taking the water from the ice mass in the valley west of Cynthiana developed the gorge by cutting down the col at E. The main

volume of the water flowed over the col at P and developed the Brush creek gorge. As climatic conditions prevailed and the ice began to recede from the heads of these valleys the volume of water which filled the outlet streams at E and P remained large and excavated large valleys in the ground moraine thus exposed and cut deep and wide gorges in the rocks at E. and P. As soon however as recession had proceeded as far as Paint creek this new channel was taken by the glacial waters and the water in Brush creek was suddenly reduced from a considerable torrent to a small stream fed only by meteoric waters. As the volume of the water was reduced suddenly there was no opportunity for the development of terraces in Baker's Fork of Brush creek. Subsequent erosion has resulted in the partial filling of these gorges and the present state of movement is now un certain.

If the above conclusions are warranted the Beech Flats must then be considered as a portion of the great level topped ground moraine so extensive within the limits of the ice movement in the portions of the State to the north and west of the Flats.


MAP
of
BEECH FLATS
by
W. G. Tight
ROSS
HIGHLAND
PIKE
ADAMS
BEECH FLATS
Paint Cr.
Bainbridge
Rocky Fork
Barrett's Mills
Carmel
Marshall
Cynthiana
Fort Hill
Brush Cr.
Sinking Springs
Sun Fish Cr.
LEGEND
County Lines





BULLETIN

OF THE

Scientific Laboratories

OF

DENISON UNIVERSITY.

VOLUME IX.

PART II

With 11 Plates and 5 Figures.

EDITED BY

W. G. TIGHT, M.S.,

Department of Geology and Natural History.

CONTENTS.

GRANVILLE, OHIO, MARCH, 1897.

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GRANVILLE, OHIO, MARCH, 1897.

I.

WAX MODELING FROM MICROSCOPIC SECTIONS.

By W. E. Wells.

[*Read before the Scientific Association at its Regular Meeting, Jan. 16, 1897.*]

In the morphological and comparative study of organic structures the value of wax modeling cannot be over-estimated. In view of this fact, and owing to the apparent scarcity of literature on the subject, a brief outline of methods employed in the Biological Laboratories of Denison University, is here given.

Models may be divided into two classes: wax or clay models, which are moulded by hand, and wax and card-board models, which are constructed from microscopic sections.

Models of the first class are built up from observed form in gross dissection and will not be described in detail here.

Wax Modeling from Sections. This method consists, essentially, in constructing enlarged patterns of a series of microscopic sections, and from these patterns constructing a model which will represent the original unsectioned tissue, but on a greatly enlarged scale.

Wax. The material best suited for such modeling is ordinary beeswax. The beeswax of commerce is either bleached or unbleached. The unbleached, by virtue of its greater plastic property, is better suited for modeling. The least tendency toward brittleness becomes a source of trouble in the cutting process.

A medium sized model, measuring in its three dimensions, 6x3x2 inches, requires about one pound of wax, including necessary waste.

Commercial yellow wax may be had at a cost of from 40c. to 60c. a pound. Bausch & Lomb furnish a special modeling wax at 55c. a pound, in bulk, or in sheets of uniform thickness, at $1.12 a dozen.

Wax Sheets—Method for Casting. The wax sheets on which the sectional drawings are to be traced, must be of definite thickness, for if the length and breadth be magnified, the thickness must also be in direct proportion.

In rough modeling where general morphological relations only are sought, the thickness may be estimated, and sheets made accordingly.

In that case, the wax may be cast in shallow boxes, constructed from heavy oiled paper.

But in order to secure scientific accuracy, and usually this is desirable if not essential, it is necessary to have the wax sheets of known and exactly uniform thickness. In order to secure such sheets a casting box is necessary. A moulding box such as is used in the chalk plate engraving or stereotyping process answers every purpose. Such box may be improvized by using two perfectly smooth metal plates of suitable size. Between these plates, and on three sides, are placed narrow metal strips of the required thickness. The plates, having been previously warmed and oiled, are clamped together and the melted wax run in. The secret of obtaining good results lies in having the plates at just the right temperature. If too cool, the chilled wax will have a striated uneven surface. If too warm upon attempting to remove the sheets the wax will be found adhering to the plates. Care must be taken also to pour the wax in a steady stream, otherwise the sheet will contain air bubbles. It is necessary, moreover, to oil the plates before each casting. Vaseline is best suited for this purpose.

Tracing. The patterns are traced on the wax sheets by the aid of the camera lucida or the projection microscope. An ordinary lead-pencil or a porcelain stylus is used for the purpose of tracing. The latter is better followed by the eye on the dark wax background.

It must be remembered that the optical principles involved in the camera lucida require that the drawing surface shall be tilted toward the microscope twice as many degrees as the mirror is depressed below 45 degrees. Often when the magnification is high, or the object large, it becomes necessary to move the section in the field, which in turn necessitates a corresponding change in the position of the wax sheet. This is not only a tedious process, but necessarily introduces errors and is entirely obviated with the projection method. Often the desired magnification requires sheets too thin to work with. Such an obstacle may be met, if every other or every third section be drawn on sheets twice or three times the estimated thickness.

The latest development in wax modeling, as originated in our laboratories, is the process of wax tracing by means of the microscopic lantern projector.

A small movable screen is used on which to project the sections. By moving this screen in the focal plane, a graduated scale is made out to indicate different magnifications. On the screen is a frame

which serves the purpose of a holder for the wax sheets. The magnification being determined upon, the wax sheets are cast with a corresponding thickness. The screen is placed at the proper distance as indicated by the scale, the images on the slides are projected in their serial order and the patterns traced on the wax sheets.

In case much detail is required, the contrast may be increased by covering the wax surfaces with thin white paper, and then tracing with a pencil, the pressure of the point being sufficient to transfer the outline to the wax beneath.

The advantages of this method are at once evident. In the first place it is labor saving. An entire series may be patterned within the space of an hour or two. Large models may be constructed without the extremely tedious process of moving the wax sheet while tracing, as is necessary with the camera lucida. And also, almost absolute accuracy is insured, which by the usual method is difficult to obtain, owing to the obscure field and possible lateral distortion of the camera lucida. It is only necessary to use an objective which will include all the field desired as the magnification depends upon the distance of the sheet from the lantern.

Cutting out Sectional Drawings. After the sections have been outlined on the wax sheets, they are to be cut out in serial order. This may be done, either with an ordinary pen knife, or better still, with an apparatus designed especially for this purpose. It consists of a wooden frame, between the two free ends of which a fine piano wire is stretched. The tension of the wire is varied by a thumb screw. A platform is attached to the lower arm, the wire being passed through a perforation in the center. As shown in Fig. 1.

When in use the apparatus is clamped to a table. The cutting is accomplished by simple pressure of the wax sheet against the wire. The smallest piano wire, with a diameter of from .037 to .035 of an inch, should be used. Experiments in heating the wire by electricity have so far proven unsatisfactory. For when the heat is increased to the proper degree, fusion of the cut edges takes place. All the sections can be cut at once, and then built up, or if only a small quantity of wax is available, the cutting and modeling may be carried on together section by section. Thus the waste may be used for casting additional sheets. If the first method is followed it is well to number the drawings to guard against any misplacement in the final reconstruction. When the sections have been fitted, they are cemented to-

gether by means of heat. The model is finally glazed over by being held for an instant over a hot flame.

Some models require mounting on a wooden base while others from the nature and position of the parts represented, show off to better advantage without any permanent base support.

Painting. To preserve and beautify the model, it should be painted. This also serves as an excellent means for differentiating the various parts. At Denison University a uniform series of colors are

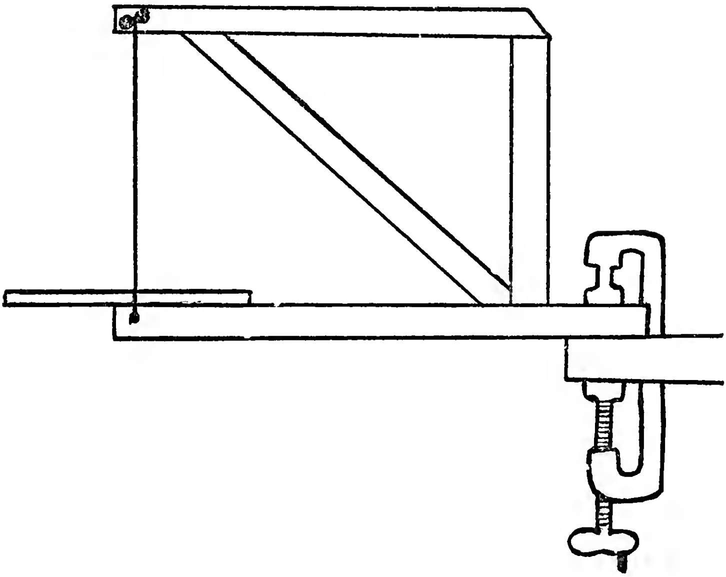


Fig. 1.

used to designate the different tissues. Thus, yellow always indicates nervous tissues, drab is used for epithelial tissue, red for glandular and black for bone and cartilage. White is generally used for painting permanent bases or supports on which the models are to be mounted. Each color should be laid on and allowed to dry separately. This prevents any running together of colors.

For black, turpentine asphaltum is unexcelled, for red and yellow tube paints answer very well. They require however, to be thinned out with a small quantity of turpentine. In fact all paints used for this

purpose, should contain some dryer, such as turpentine or Japan dryer because the wax but poorly absorbs the oil.

Labeling. Labeling the different parts, adds greatly to the future value of the model. Any good mucilage answers the purpose of an adhesive, and is preferable to glue.

Modeling Instruments. Modeling instruments may be had from any biological supply house. However, those most necessary may be improvised without much trouble.

One of the most useful modeling tools is made by fitting a small spoon into a wooden handle. With this simple instrument almost the entire process of modeling may be carried out.

Another convenient tool is an ordinary long bladed knife. For rounding out concavities, a small iron bar with a spherical enlargement at one end, and fitted with a wooden handle, is a useful accessory.

Card-Board Modelling from Microscopic Sections. This method is a modification of the former. But serves to represent, in addition to form and relation of parts, the *histological elements* which enter into the tissues.

The process is essentially the same as that for wax modeling, except that the sectional patterns are traced on card-board instead of wax, and mounted on wires in a frame, instead of being fitted and cemented together.

After the sections have been cut out, the minute histological structures are sketched on each one, from a microscopical examination of the corresponding sections in the series.

Two or more wires are stretched within a light frame-work, in such a manner that the model is suspended in the required position. In each of the card-board sections, are two or more slots, through which the wires are to pass, when the sections are in position. The sections are separated from each other by small beads which are strung on the wire for that purpose.

By such an arrangement any section may be taken out of the model and its histological structure readily seen.

II.

ELECTRICAL WAVES IN LONG PARALLEL WIRES.

By A. D. COLE.

Read before the Am. Assoc. for the Advancement of Science, at Buffalo, Aug. 1896.

The experimental study to be described in this paper was undertaken as a preliminary to a research on the refractive index of certain liquids for electrical undulations as deduced from a measurement of the ratio of wave-length in the material under investigation to that in air. That research has been published in *Wiedemann's Annalen* (February, 1896) and in full abstract in the July number of the *Physical Review*, but so many facts not hitherto described were noted in the preliminary study that I have ventured to bring them before you in the present paper.

Stationary electrical waves were produced in two long wires according to Lecher's modifications of the original method of Hertz. The apparatus used is shown in Fig. 1.

I is an induction coil capable of giving a spark several centimeters long. Wires from its secondary terminals are joined to the two primary plates $P\ P'$, the latter being connected (except for a spark gap 2 to 4 mm long) by short rods terminated by brass balls.

The distance between the primary plates could be varied by sliding these rods in their support, and the resulting changes in the capacity and self-induction of the system controlled the oscillation period. The primary plates were 40 cm. square and from 3 to 10 cm. apart. From the oscillations set up in these by the discharges of the induction coil, oscillations were induced in two secondary plates, $s\ s'$, each 10 cm. square, placed a few centimeters in front of the primary plates. To the centre of each secondary plate a long wire was attached and these two wires, after approaching (as seen at $a\ a'$) to a distance of 8 cm. apart, stretched away horizontally and parallel a distance of about 4 meters. At every oscillation of the secondary plates a wave of electricity passed along each wire, was reflected back at its end and produced, by interference with new advancing waves, a system of stationary waves with alternating nodes and ventral segments, analogous to

the stationary sound-waves in a vibrating stretched string. As in Lecher's experiments, a small Geissler tube without electrodes, placed between the remote ends of the parallel wires, glowed brilliantly.

A short wire placed across the parallel wires in general caused the light to cease, but positions could be found such that the tube still continued to glow. Three such positions were found with the apparatus used. These were separated by equal intervals and marked nodal positions, any interval giving the half wave-length of the undulations in the wires. The ends of the wires and of the secondary plates form ventral segments in the resonance system. H. Rubens[1] had succeeded

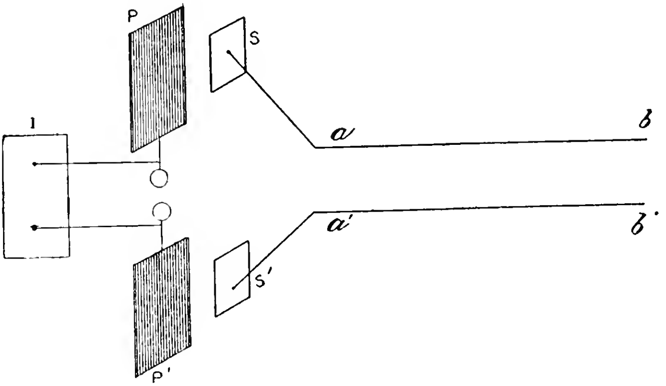


FIG. 1.

in measuring not only the length but the form and amplitude of such waves by use of the instrument devised by Paalzow and himself and named the "dynamo-bolometer." I used the same instrument employed by Rubens in his study of stationary waves in wires. Fig. 2 shows its construction. R_1 R_2 R_3 R_4 are the resistances of a balanced Wheatstone bridge. Two of these, R_1 R_2, are themselves balanced bridges, each of their four arms being a very fine iron wire about 10 cm long and of seven ohms resistance. Suppose the whole system balanced, and a weak but steady current supplied by the battery B. The galvanometer shows no deflection. Evidently if alternating currents produced by electrical oscillations enter by the wires ww' they will circulate only in the minor bridge R_2, but will disturb the balance of the main bridge by the heating effect in R_2. This disturbance, if

[1] H. Rubens, Wied. Annalen, Vol. XLII, p. 154, (1891.)

not too great, will be proportional to the heating effect producing it and this in turn, to the oscillations in the wires ww'. The galvanometer deflections become therefore a direct measure of the intensity of the electrical oscillations.[1]

To avoid disturbing the wave system in the wires, Rubens did not attach the wires w w^1 from the dynamo-bolometer directly to the points of the parallel wires to be investigated, but to little jars, made by placing around the wires bits of glass tube surrounded by shorter strips of metal foil as "outer coatings," the wires themselves forming the "inner coatings." With this apparatus, larger galvanometer deflections, ob-

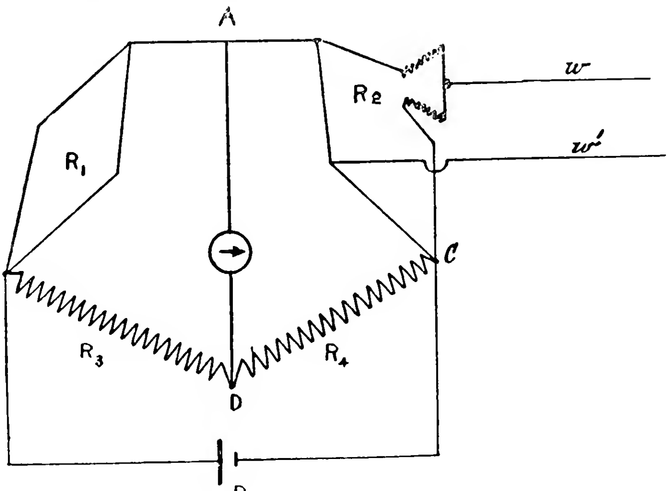


FIG. 2.

tained when the bridge wire is at a node, correspond to the glowing of the Geissler tube in Lecher's arrangement.

The wave distribution along the parallel wires was studied as follows: The Leyden jars were placed over the ends of the wires, a bridge of wire placed in a definite position across the wires (as shown by a tape measure stretched below), current sent through the induction coil, and the galvanometer deflection produced by the heating of the dynamo-bolometer read. This was repeated three or four times for each bridge position, and bridge positions taken 5 to 10 cm apart over

1. Rubens and Paalzow, l. c, Vol. XXXVII, p. 529, (1889.)

the whole length of the wire. Many such series of observations were made, the conditions being varied somewhat to learn the effect of such variations. The results may be best presented in the form of curves, abscissæ representing positions of the bridge on the wire and ordinates the corresponding galvanometer deflections in millimetres.

Rubens had noted that the number of maxima in a curve is diminished by (*a*) increasing the distance between the primary plates, and (*b*) leaving a bridge at a maximum position and exploring with a second sliding bridge.

These facts are shown repeatedly in my curves. Thus in curve D (Plate I) there are six strong maxima and seven or eight weaker ones. Abscissae represent position of the wire bridge as measured by a tape measure divided to centimeters stretched between the parallel wires, and ordinates the corresponding galvanometer deflection in millimeters. In this experiment the primary plates were 4.5 cm. apart. By increasing this distance to 8 cm. the three strong maxima (separated from one another by intervals of 146 cm.) almost disappeared, the other three remaining.

Again, by leaving a bridge in the position corresponding to the maximum nearest the secondary plates and exploring with a second bridge, all but three of the 15 maxima practically disappeared. These three occupied positions 8, 154.5 and 303.5 cm., at practically equal distances apart and are shown in curve G. The maximum near the middle of the wires was especially sharp, the two others weaker by the same amount. The effect of a fixed bridge is thus to reduce a somewhat complicated wave system to a simple one.

The maxima obtained were so improved in both strength and sharpness by the use of a second bridge that two very careful determinations of their position were made to get an idea of the degree of precision allowed by this method of calculating the half wave-length.

The results are as follows:

	Maxima.			Intervals.		Mean.
First experiment,	25.3	188.5	351.4	163.2	162.9	163.1
Second "	24 8	188 4	351.5	163.6	163 1	163.4

The nodal positions seemed to be capable of being located to within a fourth of a centimeter, and on repeating the experiment the same results could be expected within a half centimeter.

Still greater steadiness and definiteness were secured in some later experiments by the use of three or even four fixed bridges.

No change has been attributed to a change of the distance between primary and secondary plates by other experimenters, so far as I am aware; but a comparison of several of my curves seems to indicate quite clearly that diminishing this distance increases the complexity of the curve.

It is worth noting that in each of these two and three following careful determinations, the internodal space nearest the secondary plates was about 5 mm longer than the other. This also has not been elsewhere noted, so far as I know.

As it was my plan to estimate the refractive index of a number of liquids by surrounding a portion of two parallel stretched wires by the liquid under investigation, it seemed desirable to use the wires much nearer together than other experimenters or I myself had done before, in order to avoid the necessity of using a larger amount of liquid than I could readily obtain. I accordingly set up my apparatus again, with the wires only three cm apart. By this change two distinct results were produced. In the first place, the deflections produced corresponding to the maxima positions on the wire were considerably reduced in amount, viz: to about one third of the value before obtained. This was easily provided for. As the galvanometer used had been adjusted to only moderate sensitiveness, a new adjustment of it gave deflections sufficiently large. The other change noticed by bringing the wires nearer was a shortening of the interval between nodal positions. To make sure of this result and to measure the amount of the change, three complete determinations of the three maxima were made, readings being made at each centimetre on the wire near the maxima positions. The results are as follows:

			Means.	Difference.	Previous.
26.6	26.7	26.5	26 6		
187.5	187.5	187.5	187.5	160.9	163.5
347.4	347.7	347.5	347 5	160.0	163.0

The three determinations agree so well that there can be little doubt of a shortening of the internodal interval by about 3 cm or 1.5 per cent. But the true change is more than this, for the bridges themselves form a part of the resonance system, and two-thirds of their length should be added to the apparent internodal distance to get the true half wave-length. The bridges were 12 cm long in the first instance, and 3 in the second. This correction gave 171.2 as the half

wave-length for wires 8 cm apart, and 162.5 for wires 3 cm apart, a change of 9 cm, or more than 5 per cent.

It became desirable next to study the effect of surrounding a portion of the parallel wires by a containing vessel such as would be suitable for holding a liquid. I used a covered trough of zinc, 100 x 10 x 10 cm, with the wires passing centrally through rubber stoppers in the ends, one end being made to coincide with the centre maximum.

The internodal spaces, which had been equal before, were now different, that which included the metal box being shortened 3.3 cm or about 2 per cent.

The result is of the sort that we might expect, as the proximity of the metal box would naturally increase the capacity of a given length of the wires in that neighborhood, rendering a shorter length necessary.

Later experiments, in which there were two internodal spaces before the box was reached, developed the fact that the influence of the box upon the half-wave external, but adjacent to it, was considerable, since this half-wave was invariably 5 cm shorter than the one remote from the box.

When the box was filled with distilled water only a small, constant deflection of the galvanometer was obtained, and this was shown to be due partly to a direct magnetic effect of the induction coil upon the galvanometer and partly to current induced in the bolometer wires from the wires connecting the induction coil with the storage battery.

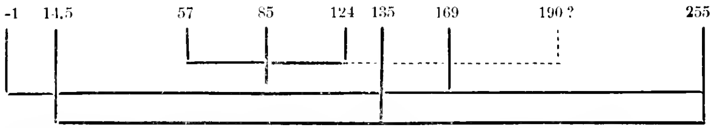
Up to this time the little "Leyden jars" had always been placed at the remote end of the parallel wires. The jars were now removed, and still smaller ones of the same sort placed at the ventral segments of the two external half waves. Although these had very small outer coatings—consisting of cylinders of copper foil 5 mm in diameter and 5 mm long—it was found that their capacity could not be neglected, but was equal to 2.5 cm wire-length. This appeared from the fact that the internodal space containing the "Leyden jar" was shortened 2.5 cm, the other remaining the same as before.

Still smaller jars were next made of a single turn of very fine wire about a glass tube 5 mm in diameter. These were found to make no appreciable change in the position of the maxima, and still, when placed at a ventral segment and connected to the dynamo-bolometer, sufficiently large deflections (100 mm) were obtained.

Very fine resonance systems were obtained in the external portion of the parallel wires in those experiments where a node was forced at

the box end,—better than had been obtained with the parallel wires alone. This result is not attributed to the presence of the box, but rather to the use of the Leyden jars at intermediate ventrals segments instead of at the ends and to the readjustment of bridges already placed whenever the capacity of the system was changed by adding a new bridge.

Thus in one experiment with bridge fixed at box end 255, nodes were located as follows:



Notice nodes at 14.5, 135 and 255 show intervals 120 and 120.5; mean 120 3.
" —2, 85, 169, 255 " " 86, 84, 87; mean 85.7.
" 57, 121 " " 67;

Thus the 9 nodal positions fall into three groups, showing intervals of 12.3, 85.7 and 67 respectively.

$$\begin{aligned} \text{Now } 120.3 \times 2\tfrac{1}{2} &= 301 \\ 85.7 \times 3\tfrac{1}{2} &= 300 \\ \text{and } 67 \times 4\tfrac{1}{2} &= 302 \end{aligned}$$

i. e., according as the nodal position occupied belonged to group 1, 2 or 3, the vibrating system consisted of 2½, 3½ or 4½ half waves, the system of wires and end plates being equivalent to 301 cm of straight parallel wires.

These results gave a simple means of calculating the parallel-wire equivalent of the secondary plates and their connecting wires. As the parallel wires began at -8 of the scale, the first node (-2) is 5 cm from one end, but the whole part of the system beyond this node $= \frac{86}{2}$ or 43 minus 5 = 38 as the equivalent in cm of the parallel wires for the capacity of each plate (6 x 6 cm) and of the 11 cm of wire leading from it to the parallel wires.

From another system of nodes we get in the same way the same result. Thus:

$\frac{120}{2} = 60$ minus $(7 + 14.5) = 38.5$ or practically the same as before.

From another experiment with a system of very different length of parallel wires, the wire equivalent of the same plate came out 39.2 and 40; mean, 39.6.

The distribution of energy in the internodal spaces was next investigated. Bridges were placed at two nodal positions external to the box and the Leyden jars moved from one end of the intervening half wave to the other at intervals of 10 cm. In each position four readings of the galvanometer were made and the mean values taken as ordinates for a curve whose abscissae were bridge positions, gave directly the distribution of electrical energy in the wires. For positions between successive nodes a very smooth and regular curve was obtained, which differs but little from a sinusoid. This is shown as curve N, Plate II.

When a bridge was placed at the box end, to force a node there, filling the box with distilled water left the wave system in the air-surrounded portion of the wires unchanged, but only slight and unsatisfactory traces of a wave system could be detected within or beyond the box, whether by Leyden jars placed at the end, or by those placed on the wires within the liquid. E. Cohn [1] had detected and measured the wave-length of resonance waves of this sort in water, and deduced therefrom the specific inductive capacity of water for long electrical waves. Of course the introduction of liquid, by the change in capacity, might be expected to destroy the resonance within and beyond the box, but it was hoped that by careful adjustment of a variable capacity at the end, the capacity of this part of the system might be increased exactly to some simple multiple of its former value and resonance thus restored.

These hopes proved delusive. The capacity at the ends was gradually raised by different means through wide limits, but such changes seemed to make no difference whatever in the resonance system within the liquid. This attempt was therefore abandoned, and improvement sought along the following lines: (a) securing great galvanometer sensitiveness, (b) purity in the liquids used, (c) using vessels of such materials that the liquids used would have no action upon them. Zinc had been used in earlier experiments. Now glass and glass coated with pure silver, alone were used. (d) Taking readings at very short intervals along the wire.

By the use of these various precautions well defined maxima were obtained, both with water and alcohol. (See Curve Q, Plate II). The maxima were less sharp and far weaker however in the part of the wires surrounded by water than in that surrounded by air. Since the

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[1] E. Cohn, Wied. Annalen, Vol. XLV, p. 370 (1892.)

wave-length is much shorter in the liquid, (only one-ninth as much in water as in air), it was possible to obtain as many as four nodal points within a vessel 78 cm. long. The details of this work with liquids—water and alcohol—are given in the recent paper in *Wiedemann's Annalen* before referred to.

Since the above work was done Drude has published a paper [1] on the same subject giving preference to the exciter described by Blondlot over that of Lecher. I have accordingly made and used the Blondlot exciter shown in Fig. 3.

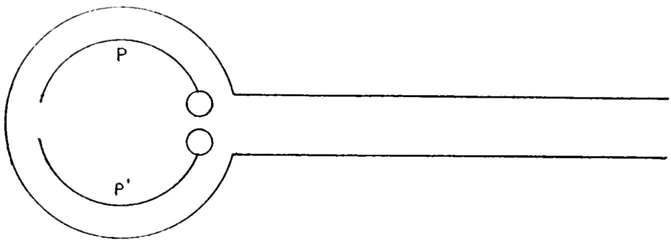
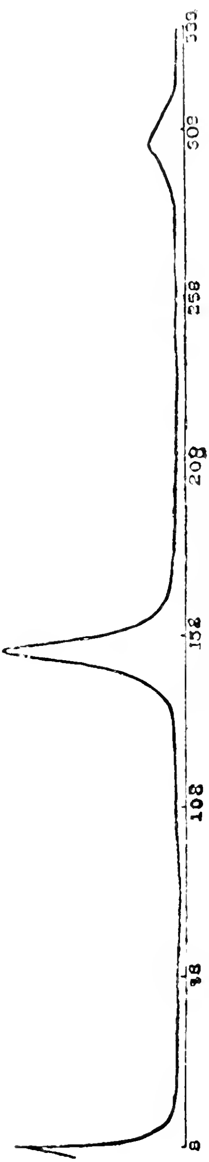


FIG. 3.

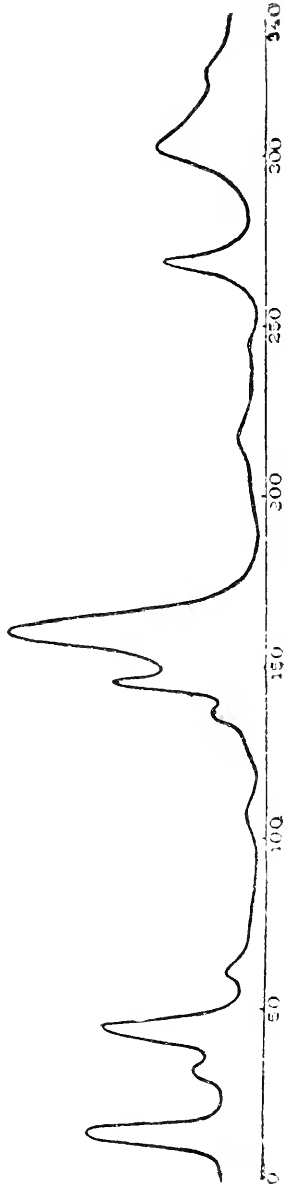
In this there are no plates, but the inner ends of the long parallel wires are joined by the circularly-curved wire of the figure. Within this wire and separated from it by only a few millimeters is the pair of primary exciters, P, P', bent to form arcs of a circle concentric with the curve of the surrounding wire, and carrying zinc balls for a spark gap at the inner ends. These exciters are connected directly to the secondary terminals of an induction coil. This form of exciter gave satisfactory results, but I have done too little work with it to make comparison with that of Lecher. I have also made successful use of the suggestion of Drude to use a Righi resonator, *i. e.* a strip of mirror amalgam with a narrow slit cut across the middle, as a means of locating nodes and loops in parallel wires. In a later apparatus of the Lecher type I have used balls of zinc instead of brass for the spark gap.

Neither Rubens nor Cohn seem to have found it necessary to protect the wires leading to the bolometer from electro-magnetic disturbances, but I have found it important. This was accomplished by enclosing them in long glass tubes which were in turn surrounded by a brass tube.

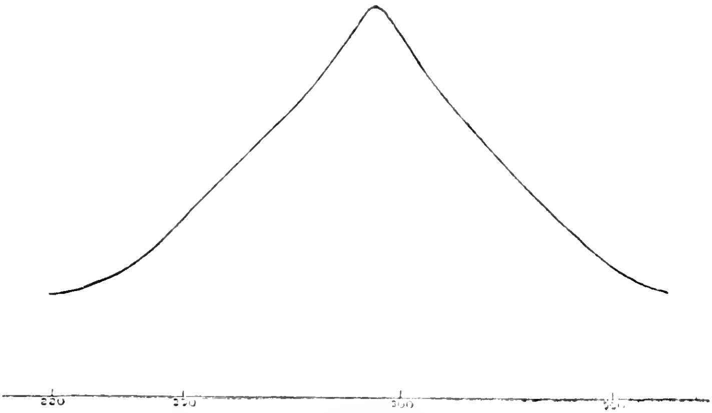
[1] P. Drude, Wied. Annalen, Vol. LV, p. 633, (1895.)



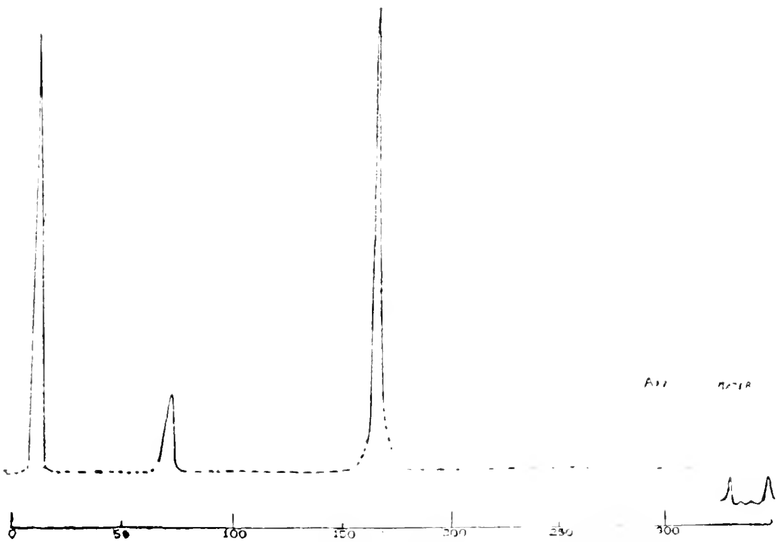
Curve G. Two Bridges.



Curve D. One Bridge.



Curve N.



Curve Q.

To recall briefly the leading points:

1. Nodes could be located on the parallel wires to within $\frac{1}{500}$ of the internodal interval.

2. Resonance systems are injured in sharpness by placing the secondary plates very near the primary.

3. The effect of diminishing the distance between the parallel wires (from 8 to 3 cm.) is to (*a*) reduce the energy of the stationary waves to one-third of their former value and (*b*) to shorten the internodal interval.

4. The wire-equivalent of the capacity of the secondary plates is practically the same, when the wave length is considerably changed. This does not harmonize with the experience of Lecher.

5. If the parallel wires are made to pass through a vessel of water 70 cm. long, capacity added to the remote ends does not affect the resonance system in the wires, either within or without the vessel.

Most of the experimental work described above was done at the University of Berlin under the direction of Dr. H. Rubens, but the later portion in the laboratories of Denison University, Ohio.

III.

CHANGES IN DRAINAGE IN SOUTHERN OHIO.

By FRANK LEVERETT.

With One Plate.

In connection with a study of the Ohio Valley and its tributaries, carried on for the U. S. Geological Survey, for a period of several months the past year (1896), I was so fortunate as to discover an abandoned valley departing from the present Ohio at Wheelersburg, Ohio, about ten miles above Portsmouth, and passing northward in a somewhat winding course to the Scioto River opposite the city of Waverly. (See map, Plate II). The valley is fully a mile, and perhaps 1½ miles in average width, and is cut to a depth of nearly 300 feet below the general level of the bordering upland, and to within about 150 feet of the present level of the Ohio. A part of this valley was long since noted by Dr. Edward Orton as the channel of a large stream, but its connection with the Ohio was not worked out. (Geology of Ohio, Vol. II, 1874, pp. 611-12).

This valley is plainly the channel of a north flowing stream, and carried the Great Kanawha and Big Sandy drainage, as well as that of several smaller tributaries of the Ohio, together with a small section of the present Ohio Valley. Evidence of the northward flow is found both in the slope of the rock floor and in the character of the river debris. A series of careful aneroid determinations indicate that the rock floor falls 25 feet in passing from Wheelersburg to Waverly, a distance by the windings of the valley of about 30 miles.

On the rock floor is a deposit of well rounded pebbles and larger stones such as characterize river bottoms. These deposits though now covered with 25 to 50 feet of silt are exposed by modern ravines which show them to be usually several feet in depth. The stones range in size from a foot or more in diameter downward to fine pebbles.

The significant feature in connection with this river debris is the kind of rocks. They are very largely made up of quartzite and pebbles formed from vein quartz, such as are abundant in the terraces of the Kanawha System of West Virginia. The fact that such stones

are sparingly represented in the form of boulders imbedded in the Coal Measures of southern Ohio, makes it necessary to determine whether they are of local or of distant derivation. The rarity of these boulders in the Coal Measures, however, is such as to render it improbable that the large number of quartzites lodged in the abandonded valley could have been derived from the immediate vicinity. It seems far more probable that they were brought by the Kanawha System of drainage from extensive outcrops of such rocks on its head waters, notably along New River.

This abandoned valley forms a natural continuation of the old Kanawha System, which, as shown some years ago by Prof. I. C. White (Appendix to Wright's Glacial Boundary in Ohio. Western Reserves Hist. Socy. Cleveland, Ohio, 1884, page 84), and discussed more fully later by Prof. G. F. Wright (Bulletin U. S. Geological Survey No. 58, 1890, pp. 86-88), discharged westward from near St. Albans, W. Va , through the abandoned channel known as "Teases Valley," to Huntington, W. Va., and thence down the present Ohio. There is a slight departure from the present course just below the mouth of the Big Sandy, near Ashland, Ky., where for a few miles it passed through a broad channel lying just south of the present south bluff. This channel back of Ashland was long since noted by Mr. Lyon of the Kentucky survey, and afterwards described by Prof. E. B. Andrews of the Ohio Survey. (Geology of Ohio, Vol. II, 1874, p. 441). The course of these abandoned channels may be seen on the accompanying map, Plate II.

The old rock floor of Teases Valley stands about 650 feet above tide, or very nearly 150 feet above the present Ohio at Huntington. The rock floor of the old channel, as preserved in numerous remnants between Huntington and Wheelersburg, shows about the same rate of descent as the present stream. At Wheelersburg it stands about 625 feet above tide. Following the abandoned valley north the rock floor descends to about 600 feet at the point where it joins the Scioto, opposite the city of Waverly. Teases Valley, and also the channel back of Ashland, and the remnants along the border of the present Ohio, all carry a deposit of rolled stones made up largely of quartzite, and similar in every way to the deposits of the abandoned valley leading north from Wheelersburg.

In the portion of southern Ohio east of the Scioto, from the present Ohio northward at least to the Hocking, the streams now directly

tributary to the Ohio, have in several instances been greatly enlarged at the expense of streams tributary to the southern end of the Scioto Basin. A reference to the accompanying map will show that the present drainage systems are very abnormal. There are suggestions of still greater changes not yet worked out to a demonstration. The Little Kanawha, with also several smaller southern tributaries of the Ohio, and a considerable portion of the Ohio itself above Huntington, may have discharged somewhat directly westward to the Scioto Basin across southern Ohio, instead of taking the roundabout course by Wheelersburg. I have only examined a part of the district which would be traversed by such a line or lines of discharge, so cannot speak with the confidence that I do of the other changes noted, but the following statements may be made.

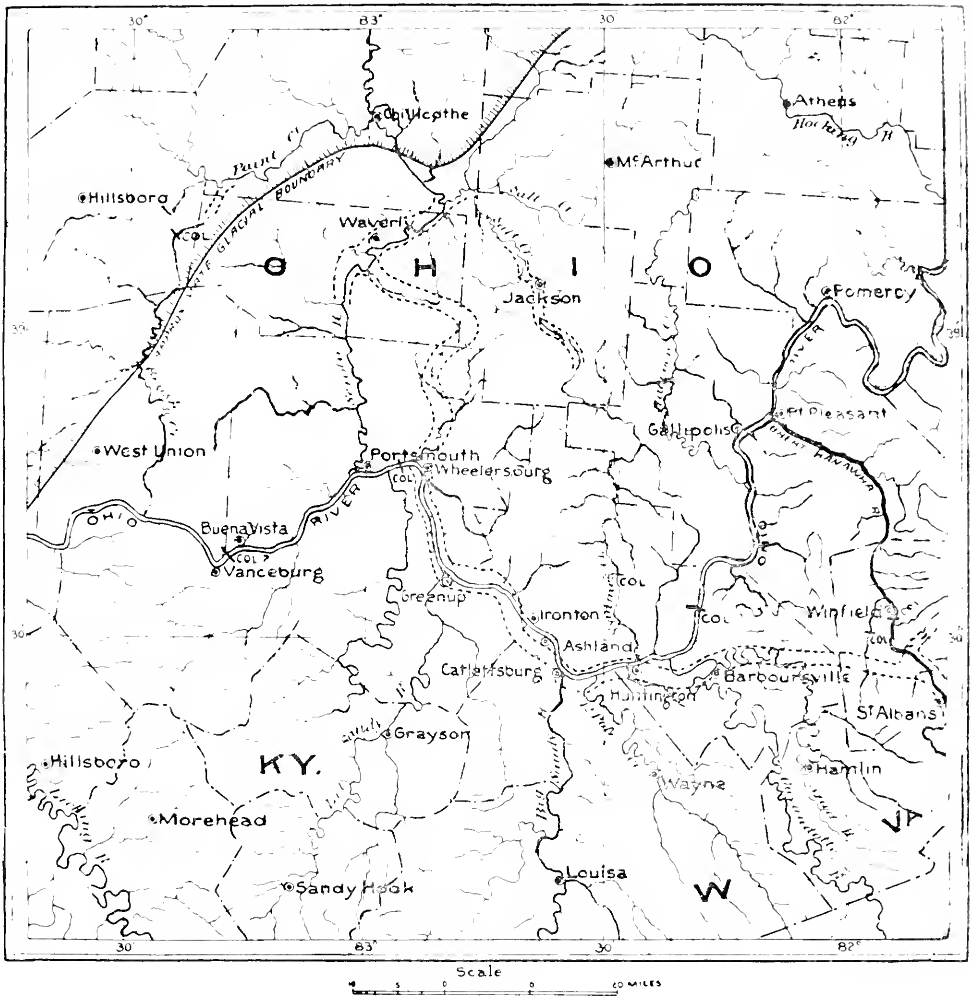
It is thought that this westward flowing system may have received drainage lines from nearly as far southwest as Teases Valley, and that in developing the present Ohio System a col may have been crossed by the Kanawha near Winfield a few miles north of St. Albans, and by the Ohio only a few miles above Huntington.

It is evident that the great part of the present drainage basin of Symmes Creek was once tributary to the Scioto through Salt Creek, there being a broad abandoned channel leading north past Camba, connecting its head waters with Salt Creek, near the city of Jackson. (See map, Plate II.)

A probable change is to be found in the lower Scioto Valley. This may have once received the several small streams which flow in a northeasterly course and enter the Ohio nearly opposite the mouth of the Scioto, and then have carried the waters north to join the old Kanawha at Waverly. This small drainage basin would include also that portion of the Ohio (reversed) between Buena Vista and Portsmouth. There is a bare possibility, however, that the Kanawha System turned south at Waverly, and followed down the Scioto and Ohio.

The northern part of the Brush Creek drainage basin certainly was once tributary to the Scioto, as indicated by Messrs. Tight and Fowke in a former bulletin, and it is possible, as suggested by Professor Tight, that the entire Brush Creek drainage basin once had northward discharge into the Scioto Basin, carrying with it a small section of the Ohio between Vanceburg, Ky., and Manchester, Ohio.

Concerning the direction of discharge for the old Kanawha System from the south end of the Scioto Basin, but little is known. The



EXPLANATION OF MAP.

The course of the old Kanawha System from St. Albans, W. Va., to Waverly, Ohio, is indicated by dotted lines representing the breadth of its channel. The northward discharge from the Symmes Creek drainage basin is similarly shown.

The position of cols is indicated by a cross bar. In cases where some doubt is felt concerning the col a query mark (?) is affixed.

The vagueness of the glacial boundary in this region is such as to render it difficult to determine with accuracy. It should be noted that the boundary here represented lies a few miles outside the lines which Prof. G. F. Wright has published. The departure however seldom reaches 10 miles.

heavy deposits of drift in central, northern, and western Ohio, render it very difficult to trace a northward line of discharge. There are at least four possible courses to be examined: 1. Southward, down the Scioto from Waverly to the Ohio, and thence down the Ohio; 2. Northward along the axis of the Ohio Basin to Lake Erie; 3. Northwestward across western Ohio, along one of the several deep valleys brought to light in that region by the oil and gas wells; 4. Northeastward past the Licking Reservoir, and along the old valley (brought to notice by Professor Tight in a former Bulletin), to the Muskingum at Dresden, thence northward along or near the present valleys of the Muskingum, Tuscarawas, and Cuyahoga to Lake Erie at Cleveland. I have thus far been unable to rule out any one of these lines as an impossible one, or to reach any satisfactory conclusion concerning the probabilities of the case.

Of the three most influential factors likely to have been potent in causing the changes of drainage in this region, uplift, stream piracy, and glaciation, the last mentioned is the only one known to have been an effective cause. That it is the only important factor is however by no means certain. The question of the cause, or causes, of the changes should therefore be left open.

Washington, D. C., January 18, 1897.

IV.

SOME PREGLACIAL DRAINAGE FEATURES OF SOUTHERN OHIO.

With Plates.

By W. G. Tight.

[This paper was presented to the Ohio Academy of Science at its winter meeting, Dec. 26 and 27, 1896, under the title of "The Big Kanawha Drainage."]

Contents.

1. INTRODUCTION.

In the Spring of 1895 it was my pleasure to spend some time in field work in southern Ohio and parts of Kentuckey and West Virginia. The results of that work were at once prepared for publication but were withheld on account of the fact that it did not seem that sufficient work had been done in the field in a certain locality to complete the data in hand and arrive at a satisfactory conclusion. The desired data have recently been obtained and inserted in the original manuscript in the proper location with the necessary alterations.

Lest there should be some misunderstanding it seems best to state here certain facts with reference to the investigation of this region in question. As will appear later in this paper in their proper order the following facts were determined during the investigations in 1895. (1) That there was undoubtedly an old col in the Ohio Valley just above Portsmouth. (2) That there was an old high level valley running northward from the Ohio Valley between Sciotoville and Wheelersburg. (3) That there was an old valley opened eastward from the Scioto

valley just north of Piketon and opposite Waverly. (4) And from Dr. Edward Orton's description in the Ohio Geological Survey, Vol. II, p. 611 that there was an ancient drainage feature in southeastern Pike County.

In the spring of 1896 Mr. Frank Leverett, of the United States Geological Survey, while engaged in field work in Ohio, called on me and I gave him the results of my work. I also stated to him at that time that it was my opinion, if as I suspected a continuous valley should be found to extend from Sciotoville northward past California Flats to the Scioto valley at Waverly, it must be connected with the "Flat Woods and Teazes Valley drainage and substantiate more fully the general drainage line indicated in my former article in this series, Vol. VIII, Part II, Plate V.

He at once planned to visit the region and after about two weeks in the field Mr. Leverett returned and reported that he had found it as expected and had traced the valley all the way from Wheelersburg to Waverly. Some months later it was possible for me to visit the region also and the data given in this article and shown in the plates and map were obtained during my visit. As the credit of first establishing this old valley belongs to Mr. Leverett I asked him to contribute to this series his interpretation of the region. He has complied and article III of this series and volume is from his hand. Whatever similarity the reader may find in the substance of these two articles or the plates presented with each should be taken as increased evidence of the truthfulness of the observations and conclusions as the two are of independent origin, except so far as stated above.

2. SOME FEATURES OF THE OHIO RIVER VALLEY.

The great trough of the Ohio river presents many problems of interest to the geologist and within a few years some new and startling theories have been advanced with reference to certain cycles of its development history. The truth or falseness of these theories remains to be proven by the accumulation of evidence for or against them.

In a former part of this series Vol. VIII, Part II, page 60, the writer expresses the belief that the Ohio river valley, in the portion along southern Ohio, is made up of modified parts of other preglacial drainage systems and its present position largely determined by the position of the lowest cols between the various elements.

The object in mind in the field work was to see if sufficient evidence could be found on which to locate these old cols. The task is by no means an easy one on account of the size of the valley and the vast amount of erosion which has taken place through the entire length of the valley. While the data here presented are not of a very exact nature from the fact that the time which it was possible to devote to the field work did not permit of detailed measurements, except in a few cases; yet it is hoped that they may be of value in suggesting fields for future investigation.

The section of the valley included in this study extends from several miles above Huntington, West Virginia, to Vanceburg, Kentucky. The points to be considered are principally the width of the valley, measured from the point of intersection of the flood plain or terrace filling with the base of the rock wall on one side to a corresponding point on the opposite side; The character of the slopes of the rock walls whether steep and precipitous or gently sloping; the stratigraphic relation and character of the rock as to its disintegrating properties; the elevation of the valley walls above rock floor and present water level; the presence of elevated rock and gravel terraces; and the character of tributary valleys. While it may be possible by such characters to locate the position of old eroded cols in the valley modifications of small streams to within a few hundred yards. (Article V.) One would be fortunate to locate by detailed study the cols of such a valley as the Ohio within a few miles, unless the characters were very evident. The section of the Ohio from Vanceburg to some miles below Manchester will be considered in an other article, now in preparation, on the Brush Creek drainage. Suffice it here to say that in the vicinity of Vanceburg and for some miles below the valley of the Ohio is relatively narrow. In places it was estimated to be less than a mile wide. The bordering hills are high and precipitous. The rocks are exposed in vertical cliffs with sharp upper angles; although composed of shales, limestones and sandstones which are not especially resistant to disintegration.

Passing up the river towards Portsmouth the valley grows wider and the bordering hills while fully as high do not have as abrupt faces towards the river front. Although the slopes are everywhere at high angles. About 4 miles below Portsmouth near Scioto Heights at the mouth of Rock Run there is a rock platform of considerable extent which appears very much as though it might be an old gradation plain,

although no stream trash was certainly identified upon its surface which is about 130 feet above the river. Scioto Heights rises, with about a 45° slope, to 510 feet above low water in the Ohio. Here the Ohio Valley is estimated at one and a half to two miles wide. The valley widens perceptibly above the mouth of Kinniconick Creek which meets the Ohio from the south west flowing in the opposite direction to that of the Ohio. Passing up the Ohio toward Portsmouth the valley of the Ohio seems to be directly continuous with that of the Scioto. The Scioto valley at its mouth is some wider than the Ohio immediately below. If a stranger unfamiliar with the facts would not observe the volume of the waters in the Ohio above the mouth of the Scioto and the latter stream, but would base judgment on the form, size and directions of the valleys, the Scioto would be taken as the continuation of the Ohio Valley as it is seen approaching the junction of these streams both from the Scioto and lower Ohio valleys. The Ohio valley immediately above Portsmouth is scarcely a mile wide while bold cliffs of Waverly shales and sandstones face the stream on both sides of the valley.

A few miles further up the river the valley grows wider and receives a considerable tributary, Tygart's Creek, from the southwest. At this point also the valley bears to the northeast toward Sciotoville and in this direction the valley also increases in width.

At Sciotoville begins the great bend in the Ohio valley towards the south and southeast. Here also enters from the north the Little Scioto river which as will be shown later is a reversed stream with a deep valley cut out of a former drainage system.

Continuing up the Ohio valley almost due south to Greenup the valley is much wider. The bordering hills do not rise to the level of the cretaceous peneplain until some distance back from the immediate valley walls. The travelers on the river steamers do not seem to be so shut in but enjoy a more open and extended view or may do so if their eyes are open to the world around them.

The old drainage level valley known as "The Flat Woods" which runs parallel to the Ohio on the Kentucky side back of Ashland will not be described. The reader is referred to the literature on the subject as found in Kentucky Geological Survey, described by Mr. Lyon; Ohio Geological Survey by E. B. Andrews Vol. II, Page 441; by Prof. G. F. Wright, Vol. V, Page 765.

At Catlettsburg the Ohio receives a large tributary from the south, the Big Sandy. The Ohio valley is perceptibly wider below the mouth of the Big Sandy than above it.

At Huntington the Ohio Valley is about one and three quarters miles wide. Here also enters from the north through a narrow deep valley the considerable stream of Symmes' Creek.

At Guyandotte the Guandotte river joins the Ohio and at this point also the Teazes valley meets the Ohio. For descriptions of the Teazes valley the reader is referred to Bulletin Geological Survey, No. 58, page 86, Prof. G. F. Wright, Ice Age of North America, page 339, same author.

Passing further up the river the valley rapidly grows narrower. The characters of the valley resemble those noted below Vanceburg and above Portsmouth. There seems to be nothing in the stratigraphy which would produce this narrowing of the valley and the presence of the bold cliffs of carboniferous rocks. Several miles above Guyandotte the width of the valley was estimated at less than a mile. Observations were not extended farther up the river.

The tributary valleys of the Ohio to which attention is especially directed are: The Teazes valley of West Virginia and the Flat Woods valley back of Ashland, Kentuckey, both of which have been described by other writers; The Big Sandy; The California valley and Symmes' Creek.

3. THE BIG SANDY VALLEY.

Our examination of the valley of the Big Sandy did not extend above five miles from Catlettsburg and the results of the study will be briefly stated. The general direction of the valley conforms to that of the Ohio from Sciotoville to Catlettsburg. A cross section would show very clearly that the present channel has been eroded out of a more elevated valley floor. The rock platforms left on both sides of the valley show the old drainage level to be [by aneroid] about 150 feet above the present level of the Ohio. The old gradation plain is in many places very prominent. The characters of this high level valley resemble those of the Teazes, Flat Woods, and California valleys. There is no doubt in the mind of the writer that the gradient of the Big Sandy has been recently increased thus producing rapid cutting in the old gradient plain.

4. THE CALIFORNIA VALLEY.

This is the name which Dr. Edward Orton gave to a portion of an old deserted drainage line which extends from Sciotoville to Waverly along the line indicated on the map Plate III and which will be described more in detail. Dr. Orton, in his report on Pike County, in the Ohio Geological Survey, Vol. II, page 611, says: "In the extreme northwestern and southeastern corners of the connty, near Cynthiana[1] and California respectively, there are conspicuous examples of surface erosion that do not belong to either of the systems thus far named, but which are connected with the drainage systems of adjoining counties. Neither case, in fact, is explicable by existing agencies of erosion. The California valley, which is very broad and deep, is occupied by an insignificant stream that flows with a sluggish current upon the surface of the deep drift beds by which the valley is filled. The Drift in the vicinity of Cynthiana often exceeds fifteen feet in depth, and the origin of the great excavation which has here been effected must be sought in the glacial epoch, or in pre-glacial times."

Whether Dr. Orton recognized the continuation of this old drainage feature southward from California through Scioto county to the Ohio valley is not stated. But that he recognized the main features of the northern portion of the valley is very clear, so that the name which he gave to the part is here retained for the whole valley. In company with Mr. Wiltsee, of the department of geology, I examined this drainage line from the Ohio to the Scioto. The valley of the Ohio from Greenup to Wheelersburg continued northward would follow directly into the Ohio end of the California valley. North of Sciotoville and Wheelersburg the gradation plain of this valley lies about 150—175 feet [by aneroid] above the present Ohio. The rock floor gradually descends as the valley passes in a great sigmoid across Scioto county to California. Here it is estimated from well depths that the rock floor is about 100 feet below the surface. The valley next makes a great bend to the eastward into Jackson county and then westward to the Scioto. The southern portion of the valley floor has been much cut up by recent drainage lines but in many places the gradation plains are preserved and on the old valley floor was found river rubbish exactly similar to that of the Teazes and Flat Woods valleys. The little Scioto

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[1] See description, Bulletin, Vol. IX, article III, this series.

river has worked out a deep and rather broad valley in this region but a glance at the map plate III will show that the Little Scioto does not follow entirely the line of the old valley. The Rocky Fork occupies the old valley for a considerable distance, than leaves it to join the main fork and together they gain the old valley again farther to the south. There has been such a vast amount of erosion along the lower portion of the Little Scioto (and considered in connection with other characters) as to make it very probable that some of the work was done by a larger stream than the present river.

The old valley floor lies about 300 to 350 feet below the hills which border it and in no case were cliffs observed on either side of the valley although often the slopes were quite steep. The similarity in the topographic forms of this valley to those of the Teazes and Flat Woods valleys and the portions of the Ohio connecting these elements is very marked, while the dissimilarity to the forms below Vanceburg and above Portsmouth and Guyandotte on the Ohio is as striking.

In the northern portion of the valley the width increases until it is even greater than that of the Scioto below Piketon. The rock floor is here deeply buried beneath a very compact, finely laminated river silt, good sections of which are revealed in many places by recent erosion.

The descent of the rock floor also continues to the northward. The present drift plain of the valley presents a high terrace like front along the Scioto valley.

5. SYMMES CREEK AND SALT CREEK.

Symmes creek rises near the center of Jackson county and flows southward through Gallia and Lawrence counties and joins the Ohio opposite Huntington, West Virginia. This valley was studied at only two points. Reference has already been made to the character of the valley at its junction with the Ohio where the stream runs in a very deep and narrow trough which it has cut out of the carboniferous rocks.

At the head waters near the city of Jackson the stream is in a broad and open valley which it shares with the head waters of the south fork of Salt creek which latter flows northwestward into the Scioto at the great bend in the southeast corner of Ross county. The old erosion valley at Jackson is over a mile wide and is cut some 200 feet into the table lands. The valley floor rises to the southward and the width of the valley decreases somewhat in the few miles that it was examined south of Jackson. To the northward the valley broadens out rapidly

towards the Scioto. The fact that this valley was not produced by the action of its present stream was early recognized by Dr. Edward Orton for in his report of Ross county, Ohio Geological Survey Vol. II, page 642, he says: "East of the Scioto, and in the southeastern corner of the county, Salt creek flows in an old and deeply excavated valley."

Time did not permit the examination of this valley its entire length but it seems very probable that some connection may exist between this valley and the drainage basin of Raccoon creek. The location of the col on Symmes creek as shown on Plate III was made entirely from the map study and was not verified in the field so that it is only tentatively placed. The northward direction of all the tributaries and especially that of Sand creek is very suggestive of the fact of the reversal of drainage and was the principal factor considered in locating the col.

6. CORRELATION OF THE DRAINAGE AND TOPOGRAPHIC FEATURES.

The reconstruction of the old drainage lines of the region seems very plain. The main axis of drainage was the Big Kanawha, with its head waters, in New River, in the old land of the Blue Ridge, it crossed the low inland of the great Appallachian valley and the Allegheny plateau along the line of the Teazes valley to the Ohio at Guyandotte. Here it received a tributary from the north along the line of the Ohio which headed at near Millersport, also one from the south, the Guyandotte river. Its course then conformed to that of the Ohio to the mouth of the Big Sandy, thence it followed the Flat Woods valley to Greenup where it again conformed to the present Ohio to Sciotoville. At Greenup it received a tributary from the south, the Little Sandy. At Sciotoville it also received an other southern tributary, Tygarts creek, the lower portion of which conforms to a portion of the Ohio. The main stream continued northward through the California valley to Waverly where it received an other considerable tributary on its western side which was made up of the waters of Salt Lick creek and Kinniconick creek continued along their normal directions along the reversed Ohio and lower Scioto rivers. The great ridge which separates the waters of Kinniconick creek and Tygarts creek then continued northward right across the present Ohio just above Portsmouth into Scioto county and formed the water shed between the main stream and this last mentioned tributary at Waverly. The presence of this great drainage line along the California valley so close to the lower Scioto and this

old divide easily accounts for the lack of any large tributary stream on the east side of the lower Scioto.

From Waverly the main axis continued northward along the present line of the Scioto into central Ohio. At the great bend of the valley in southeastern Ross county a considerable tributary was received along what I have called the old Jackson valley. As shown by Mr. Fowke (article II this series) another large tributary was received just above Chillicothe, the Paint creek drainage.

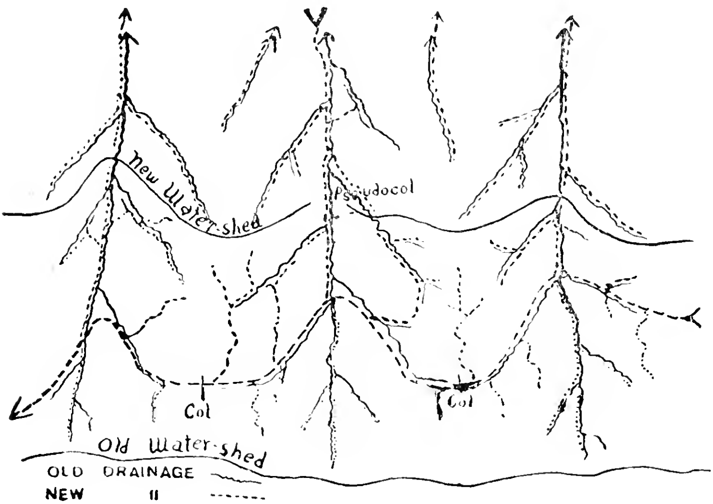
The course of this great drainage line from central Ohio may be somewhat doubtful but the writer has as yet no grounds for modifying the views expressed in his first article in this series, in which he states that the Preglacial Muskingum and reversed Scioto found a western outlet along the line roughly indicated on the map, Plate V, accompanying that article. The facts here presented and the conclusions drawn seem also in harmony with the views expressed that the Ohio river valley along southern Ohio has been developed, in very recent geologic time, from the adjacent parts of several older river systems by the cutting down of the old cols between these basins. The silting up of portions of the old channels during the back high water stage above low neighboring cols undoubtedly determined some of the important modifications. It would seem as though the filling of the northern end of the old California valley may have produced the deflection of the waters across the ridge between Sciotoville and Portsmouth. If however the waters rose high enough to occupy both courses, leaving the area included by the Ohio, California and Scioto valleys as an island it would be expected that the shortest course would be developed on account of the greater grade.

7. A PSEUDOCOL.

In determining drainage modifications it is necessary to locate with accuracy the position of the original col which was worn away in the development of the new system. To accomplish this many things are taken into consideration. The criteria will be quite different when the systems bear different relations to each other, notably when the new system is above or below the level of the old and when the new system is larger or smaller than the old. Without entering into a full discussion of this question I desire to call attention to a particular case which has come under my notice where most of the criteria seem to be ful-

filled for the location of an eroded col and yet the peculiar topographic form has been produced in an entirely different manner.

In the case in which the new system carries a larger or smaller volume of water but has not as yet reached the depth of the old system, or in other words when the new system is larger or smaller but above the old, the location of the col is partially indicated by the broadening of the valley and the descent of the rock floor of the valley in opposite directions from the col. Other adjacent streams usually indicate also the position of the divide in which the col occurred. These conditions may exist where there has been a modification and reversal of



drainage without there ever having been a col at the point suggested by the data and the divide which at first would seem, from map study, to be a part of the old form is in reality a result of the combination of the two forms. The conditions would be produced when one large drainage line is developed transverse to another with a reversal of part of the old system and an increase in the volume of water (or lapse of considerable time). The relations are indicated diagramatically in the accompanying figure in which the old drainage is indicated by the continuous wavy lines; the new drainage, by the dotted wavy lines.

The form at A resulting from this combination I have termed a pseudocol from the fact that the data so strongly indicates the existence

of an eroded col that one is apt to be misled. In the case of the true col not only the gradient of the rock floor of the valley descends from the location but also the general topographic surface descends in a direction at right angles to the true divide, while in case of the pseudocol the general topographic surface forms a continuous plain across the new system and the apparent divide as indicated by adjacent drainage lines is the balance line between the two cycles and is evidently migrating rapidly from the new drainage axis. Field illustrations of this peculiar topographic form will be given and discussed later.

Photo and Eng. by W. G. Tight.

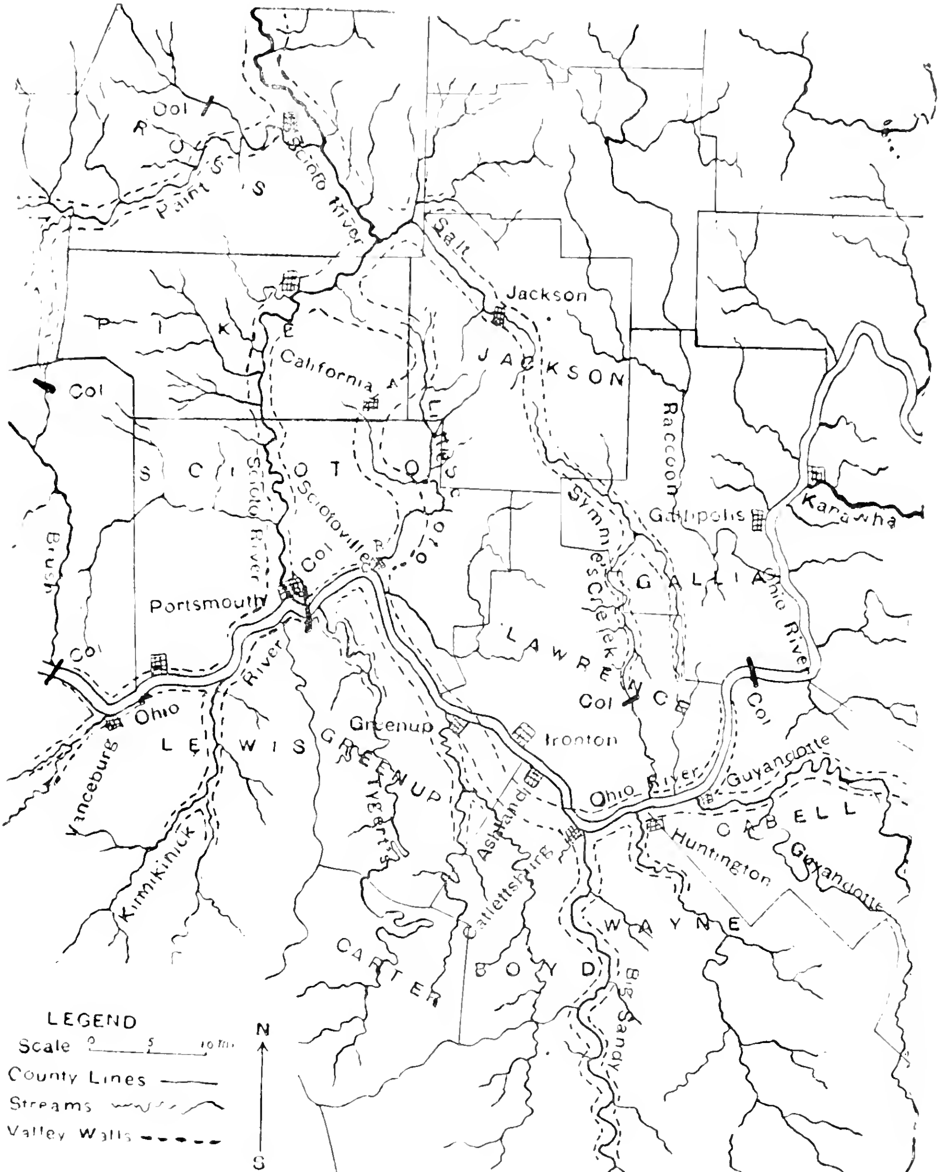
A View of "California Flats" at A, Plate III. Bordering Hills on the Left.

Photo and Eng. by W. G. Tight.

Looking up the Little Scioto Valley from B, Plate III. The valley floor of California Valley is seen in the middle distance and the old valley wall at the horizon.

Photo and Eng. by W. G. Tight.

The Ohio River. Looking towards Portsmouth from C, Plate III. The Gorge character of the Valley is shown in the distance.


Col
ROSS
Paint
Scioto River
Salt
Jackson
PIKE
California
JACKSON
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Little Scioto
SCIOTO
Raccoon
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Sciotoville
Symmes Creek
Gallipolis
Kanawha
Brush
Col
GALLIA
Ohio River
Portsmouth
LAWRENCE
Col
River
Col
Col
Ohio
Greenup
Ironton
Vanceburg
LEWIS
GREENUP
Tygerts
Ohio River
Guyandotte
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County Lines
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N
S

V.

A PREGLACIAL VALLEY IN FAIRFIELD COUNTY.

By W. G. TIGHT.

[*Read Before the Ohio State Academy of Science, Dec. 26 and 27, 1896.*]

My attention was first called by Dr. J. C Hartzler of Newark to the existence of a preglacial drainage line east of Lancaster, in Fairfield county. In company with Dr. Hartzler and Prof. Richards, of the Newark High School, I visited the region in the Spring of 1896 and together we traced a portion of the old valley. A more extended examination of the region was made in the Fall in company with Mr. C. A. Wiltsee, of the department of Geology of Denison University.

The area under consideration and shown on the accompanying map, Plate IV, includes principally Berne and Rush Creek townships of Fairfield county, and Marion township of Hocking county, and Jackson and Pike townships of Perry county. These townships are now drained by the Hocking river and its tributary, Rush creek. The river passes diagonally through Berne township, from Lancaster to Sugar Grove. A little below Lancaster it receives a small tributary, Pleasant run, and at Sugar Grove the considerable stream of Rush creek. Pleasant run rises on the drift plain of Pleasant township and flows south into Berne township. In the southern part of Pleasant township its valley is quite deep and of considerable size. On entering Berne township the stream flows out upon a broad, almost level alluvial plain. The stream bears to the westward across this plain for about two miles when it again enters a comparatively narrow valley bounded by high hills, which it follows southward to the Hocking.

Rush creek rises in the vicinity of New Lexington, Pike township, Perry county, at about 871 feet A. T., flows east to Bremen, thence south into Hocking county a short distance and then turns east again into Fairfield county. At Bremen it receives a considerable tributary, North Fork Rush creek, from the north. This branch rises on the drift till plain near Hadley Junction and Pleasantville and flows

southward through a shallow trough cut from the drift until near Rushville when its valley suddenly becomes transformed into a narrow rock gorge with the hills rising almost vertically 150 to 200 feet from the stream, with scarcely room for the railroad and the creek between the rock walls. And as suddenly does it again open out upon the broad alluvial plain of the Rush creek valley at Bremen. Two other smaller tributaries of Rush creek must be mentioned. Raccoon creek which rises near Pleasant run in Pleasant township and flows southward almost parallel to that stream, and only a mile or so east of it, until it reaches Berne township when, like Pleasant run, it flows out upon a broad alluvial plain and turns east and flows through a broad and open valley, which is nearly a mile wide, to Rush creek at Bremen. On the township line between Pleasant and Berne the rock divide between Pleasant run and Raccoon creek, is about 150 to 200 feet above the streams, while in Berne township where Pleasant run turns west and Raccoon creek turns east, the two streams are on the same alluvial plain of a broad east and west valley. In the early days when the country was new and this old alluvial plain was timbered the waters of Raccoon creek joined those of Pleasant run and flowed westward into the Hocking. Their deflection eastward was brought about by the construction the of an old mill pond and dam. The ditch dug for a waste way from the mill wheel found a slightly lower level eastward, while the natural overflow from the mill pond was westward. In time the pond filled with silt, the mill was abandoned, the wheel (an overshot) decayed, the dam also rotted away, the pond drained out through the waste way, and Raccoon creek was added to Rush creek. A few logs still remain in the bed of Raccoon creek to mark the site of the dam, the banks of the pond have disappeared under the leveling action of plow and harrow, but the whole story is told by the logs in the bed of the stream and the eight feet of silt above the buried soil, which now shows where the water has cut out its channel through the middle of the old pond.

Turkey creek rises in Monday creek township of Perry county and flows north-westward to join Rush creek, which is here flowing south eastward. Its valley is continuous in direction and conforms in depth and width to that of the Rush creek valley from the point of the confluence of Turkey creek with Rush creek to Bremen.

The topographical features in the vicinity of Lancaster can best be observed from Mt. Pleasant, a bold bluff of Logan conglomerate just

north of the city. Looking northward and westward the view extends many miles over the broad drift plain of central Ohio. The waters of the Hocking can be seen for many miles. The valleys of the streams are nothing more than shallow troughs cut out of the almost level till plain.

Southward the Hocking rivers enters the hills in a valley about a mile wide. The hills rising 200 feet on each side of the valley. Along this same valley extends the C. H. V. & T. R. R. and the Hocking canal. The valley of the Hocking grows narrower and deep towards the south. Looking eastward there is observed a broad valley equal to if not longer than that of the Hocking and uniting with the latter at Lancaster. For several miles east of Lancaster the valley is not occupied by any stream but is crossed by Pleasant run on its way to the Hocking. This valley is traversed by the almost level track of the C. & M. V. R. R. from Lancaster to Bremen.

A view from one of the hills near Bremen shows that the valley extending from Lancaster to Bremen continues eastward and is occupied by Brush creek. Just north of Bremen the North Fork of Rush creek enters the valley through a very narrow rock gorge. South of the town Rush creek turns south into a valley about three quarters of a mile broad where it joins the larger east and west valley. The observer wonders why the waters of Rush creek should turn into this smaller valley which runs back among the hills and does not continue its eastern course through the broad and open valley to Lancaster. Just east of Bremen the alluvial bottoms are veritable swamps and cover a large area. The old valley seems to have been broadened out here by its lateral tributaries. Passing eastward along the line of the C. & M. V. and T. & O. C. R. R. the valley of Rush creek narrows gradually. Tributary valleys of considerable size enter from both the north and south sides. The Shawnee division of the B. & O. R. R. crosses the valley by following two of these lateral valleys tunneling at both divides. At New Lexington the valley may be said to end. The valley floor is here about 871 feet A. T. The C. & M. V. R. R. turns north up a small branch and about three miles from New Lexington tunnels through the divide. The T. & O. C. R. R. turns south and tunnels the divide within about a mile from the city.

From Bremen southward the valley of Rush creek narrows rapidly and appears coutinuous with that of Turkey run but the stream follows a small tributary valley and where it crosses the county line into Hock-

ing county it is flowing between almost vertical rock walls 200 yards apart at flood plain. The valley again broadens toward Sugar Grove, the main valley bearing northward while a somewhat lesser valley turns southward both opening at once into the valley of the Hocking.

A few miles above Sugar Grove Rush creek deserts both of these outlets and has cut for itself a very narrow and picturesque gorge among the hills along the south wall of the old valley. The whole drainage of Rush creek seems to have been determined to run contrary to all the laws of hydraulics.

The geological structure of the entire region is upper Waverly and lower Carboniferous sandstones and shales dipping slightly to the southeast. As far as observed the underlying rock structure has had no influence in the determination of the drainage lines.

The glacial boundary through this region has been located by Prof. G. F. Wright, at Lancaster. This will serve as a general bounddary but local extentions are to be expected. Extending all along the valley east from Lancaster to a half mile beyond Junction City drift deposits, consisting of stratified and unstratified gravels and till are scattered at high levels on both north and south walls of the valley. These deposits extend for some distance south of Bremen down Rush creek but none were observed beyond the county line where an old col undoubtedly existed.

The most eastern till deposit occurs about ½ mile east of Junction City where it fills the old valley 100 feet above the flood plain of the creek and has caused a slight deflection of the stream to the south around a large island like hill of Waverly. The rail road has here made a deep cut through the till and revealed an excellent section.

Besides the high level deposits which must be attributed directly to the ice. All the large valleys are filled with river wash and silt. At Lancaster this filling in the Hocking valley is at least 220 feet deep. At a point about midway between Lancaster and Bremen rock was reached by a gas well at 175 feet. At Bremen a gas well very much to one side of the valley penetrated 65 feet of filling.

Assuming a uniform grade in the old rock floor from New Lexington to Lancaster the filling at Bremen would reach over 100 feet. At the col on county line on Rush creek, the rock is only about 20 feet below the level of the stream and about 50 feet above the valley floor at Bremen. In Rush creek valley a few miles above Sugar Grove, the rock is at least 118 feet below the surface near the middle of the valley.

From the facts stated it seems certain that the main preglacial drainage of this region was almost directly east from New Lexington to Lancaster. Tributary valleys of considerable size opened into this main valley at various points, notably one from the north at Bremen in the present position of North Fork, Rush creek. Also near same place one from the south which was the westward continuation of the Turkey creek valley.

As the ice tongue which was pushed up this valley as far as Junction City was withdrawn and while yet the mouth of the valley at Lancaster was filled with ice, the waters were ponded back until they rose over a col, located just on the county line between Fairfield and Hocking, where the present Rush creek crosses, and found their way southward into the Hocking. The position of this old col is so plainly indicated by the surrounding topography that its location can be made with certainty to within a hundred yards Just north of this valley the waters ponded back by the main ice front crossed the divide at the col near Rushville and scoured out the gorge from Rushville to Bremen, thus finding an outlet southward along Rush creek.

This torrent of glacial waters had so deepened the Rush creek drainage, line and silted up the old valleys that when finally the ice was withdrawn from the mouth of the valley at Lancaster the waters did not re-occupy their old valleys but followed the glacial drainage lines. The lower portion of the present Rush creek valley, south of the county line, was occupied in preglacial time by a stream heading in several small streamlets in the eastern portion of Marion township, Hocking county. Towards its mouth it bore to the north-westward to join the Hocking and not to the south-westward as at present.

When it is borne in mind that many facts not stated herein seem to indicate that the present Hocking is a reversed stream, it becomes apparent that these preglacial valleys conform to the original preglacial Hocking drainage and add more evidence to the support of the opinion that the preglacial Hocking ran north-westward. And this in its turn to the still larger problem of the central Ohio preglacial river system formed from northward flowing streams which crossed the present course of the Ohio river. One more link is thus added to the chain of evidence in support of the view that the Ohio river along southern Ohio owes its origin and position to glacial forces and does not date back of the glacial period.

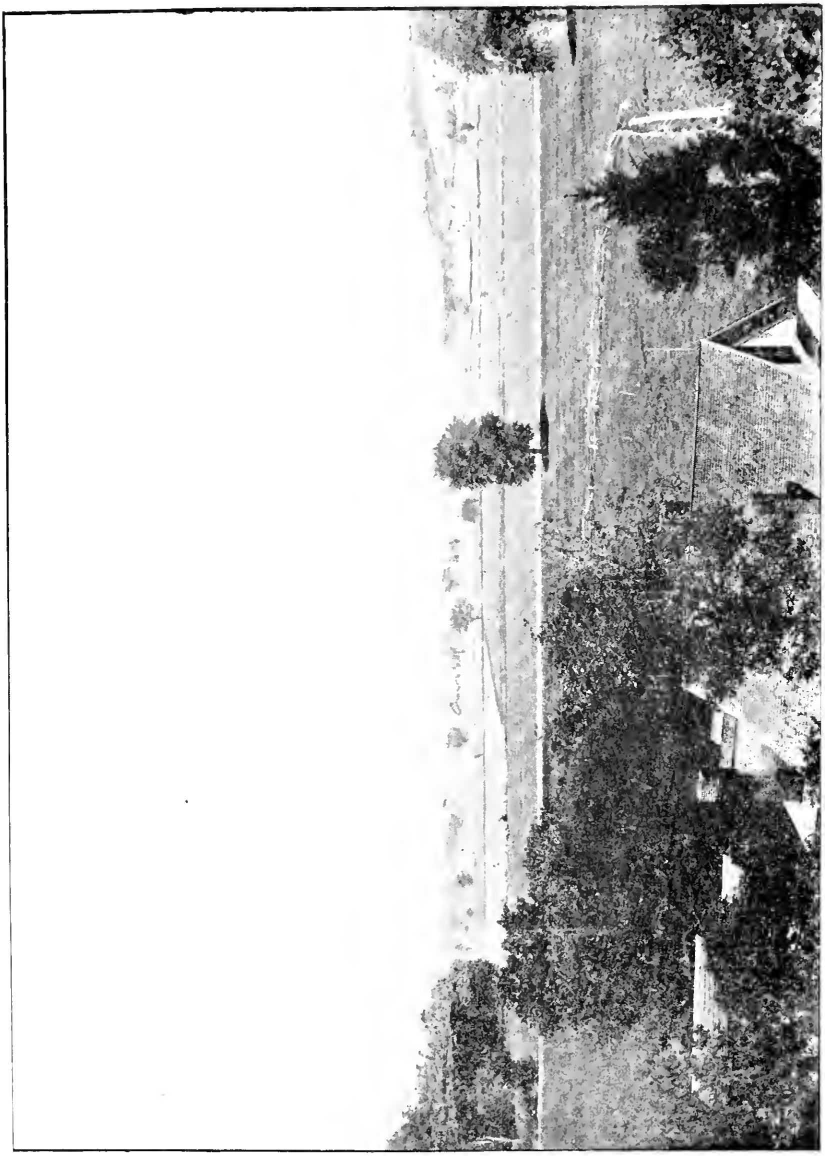


Photo and Eng. by W. G. Tight.

The Old Valley. Looking from A, Plate IV, toward Lancaster. Rolling Gravel Hills on the Left.

Photo and Eng. by W. G. Tight.

The Rocks at the Col on the County Line at B, Plate IV.

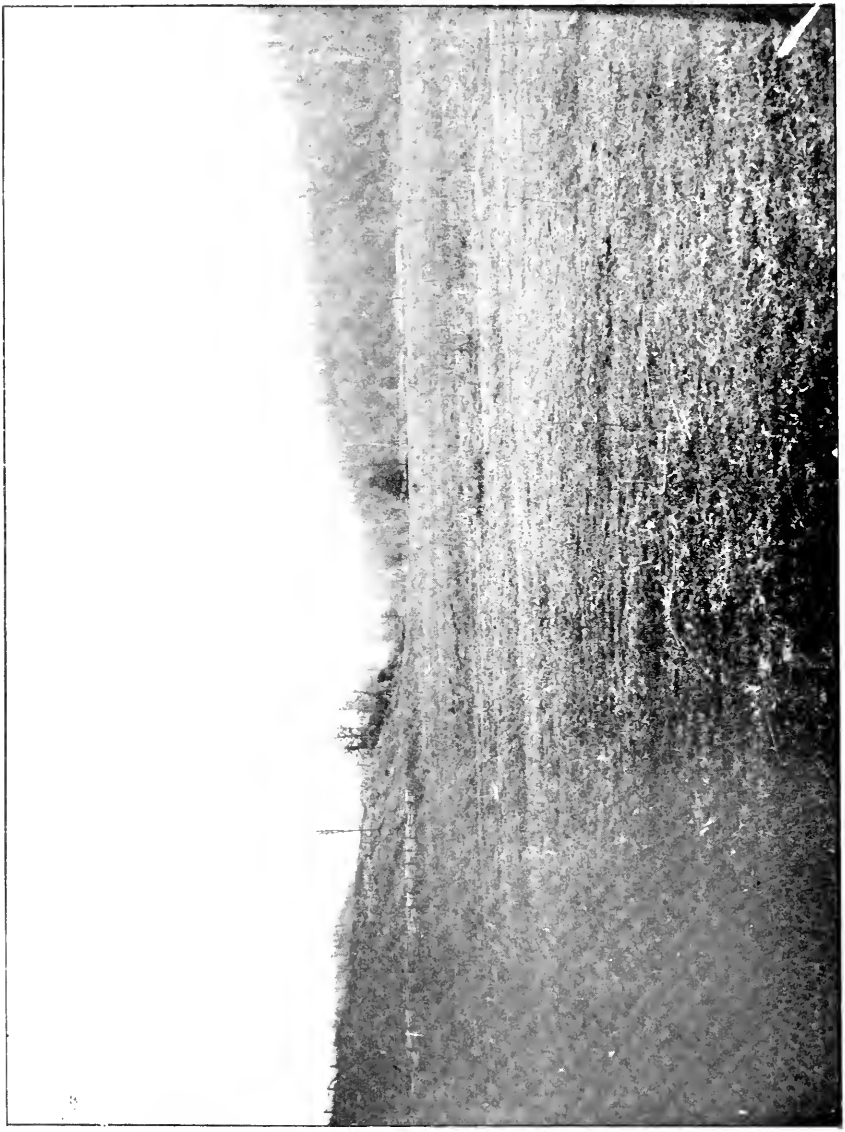
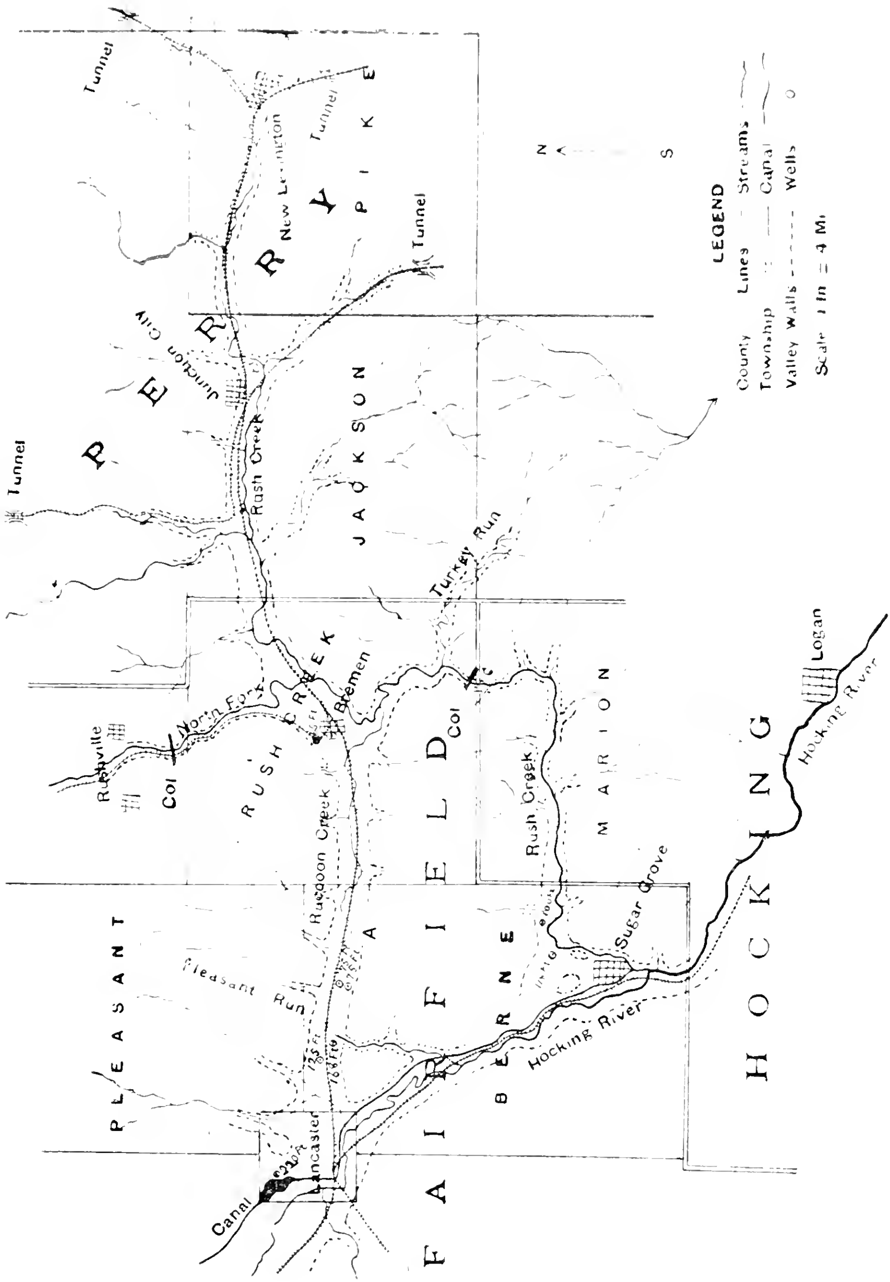


Photo and Eng. by W. G. Tight.

The Col at County Line at C, Plate IV., looking up Rush Creek. The bluff to the left marks the top of the old gradation plain.


PERRY
PIKE
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Bremen
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FAIRFIELD
Raccoon Creek
Rush Creek
MARION
PLEASANT
Pleasant Run
BERNE
Hocking River
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Lancaster
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